

# *How does the work at the ITS Institute benefit me?*



*Fewer traffic fatalities*  
(more on page 10)



*Safer rural intersections*  
(more on page 22 )



*Tools to help teens drive safer*  
(more on page 46 )



*Training and education for students and professionals*  
(more on page 38)



*Information to avoid hazardous driving conditions*  
(more on page 25)



*Faster commutes on buses that bypass congestion*  
(more on page 46)

*ITS Institute Annual Report 2009-2010*  
*Human-centered technology to enhance safety and mobility*



**ITS INSTITUTE**  
UNIVERSITY OF MINNESOTA

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Human-centered technology to enhance safety and mobility

A report of research, education, and technology transfer activities of the Intelligent Transportation Systems Institute at the University of Minnesota for fiscal year 2009–2010

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## Message from the Director

Transportation, it seems, has never been more visible in the news. Road fatalities, driver distraction, traffic congestion, environmental sustainability, economic development, and privacy—these are among the many issues included in current debates over transportation policy and technology. The work of the ITS Institute touches all of these themes.

The past year has been a period of positive transition for the ITS Institute. A number of important research initiatives have moved from development to implementation and testing. At the same time, researchers have initiated new projects that promise to open up significant new directions for ITS research at the University of Minnesota.

The Institute's ability to create innovative partnerships with transportation stakeholders in the public and private sectors, and between researchers in different disciplines, continues to be the foundation of our success. The benefit of this partnership model can be seen in the breakdown of sponsoring organizations that have funded ITS Institute research



*Max Donath*

over the last five years (see list, opposite page). During FY10, the Institute has leveraged \$3.5 million of UTC funding from the U.S. Department of Transportation's Research and Innovative Technology Administration (RITA) to attract additional funding of \$3.5 million from other federal sources and \$4.1 million from non-federal sources. The University of Minnesota and the Minnesota Department of Transportation (Mn/DOT) have been critical in supporting the ITS Institute, especially considering that we must match our UTC funding with non-federal funds. Our success was possible only because of the hard work, innovation, and creativity of all of our university constituents.

One of the Institute's key research and development efforts reached an important milestone in January, as the rural intersection decision support (IDS) system entered field operational testing. The Stop Sign Assist (SSA) system has been installed at two rural highway intersections with high crash rates, and installation at two more sites will be completed in the coming months.

Conceived as a response to the persistent problem of crashes at rural highway intersections and representing a new approach to intersection crash reduction, the SSA system was developed over the past several years with sponsorship by the Federal Highway Administration (FHWA)'s Cooperative Intersection Collision Avoidance Systems (CICAS) research initiative and Mn/DOT. After considerable

data analysis and evaluation by an interdisciplinary research team of engineers and cognitive psychologists from the Institute's Intelligent Vehicles Laboratory (IV Lab) and the HumanFIRST Program, the SSA system has taken another significant step toward its goal of national deployment.

In Alaska, a driver-assistive system designed to allow snowplows to operate safely in conditions of extremely low visibility has won kudos from Alaska's DOT. Plows equipped with the Minnesota-designed system are deployed at Thompson Pass, where annual snowfall averages 81 feet, wind gusts approach 80 mph, and temperatures fall to -60°F. This past October, a video crew followed the operators and their snowplows during a three-day storm—one of the largest ever recorded in the area in terms of snowfall. The resulting program, which aired on the Speed Channel in March 2010, showed the effectiveness of the driver-assistive system under the most extreme weather conditions and featured positive reports from plow operators. The Alaska DOT reports that the reliability and efficiency of the system has exceeded their expectations, and funding has been allocated for additional units.

Pavement research is an area not commonly associated with intelligent transportation systems, but research recently initiated at the University's Duluth campus has the potential to make pavements smarter as well as stronger by incorporating carbon

nanotubes into concrete. This approach aims to turn the road surface itself into a sensor by utilizing the unique mechanical and electrical properties of carbon nanotubes. Panels of this advanced material could one day replace conventional pressure sensors and pavement-embedded inductive loop detectors in many applications. The Duluth researchers associated with the Northland Advanced Transportation Systems Research Laboratories were successful in winning highly competitive funding from the FHWA and National Science Foundation for this research, which was featured in the February 2010 issue of *Popular Science* magazine.

The Institute's work on managing traffic at Denali National Park, featured in past annual reports, will continue with a new multi-year contract to help Denali and the National Park Service use traffic models developed by the Minnesota Traffic Observatory (MTO) to evaluate options contained in a new park transportation plan that maximizes human access to the park while protecting the area's natural beauty and wildlife.

In the realm of education, the ITS Institute maintains its focus on training the next generation of transportation engineers and policy leaders, equipping undergraduate and graduate students with the skills to innovate and solve problems in an increasingly interconnected transportation world. This year's ITS Institute Student of the Year, Fay Cleaveland, earned a master's degree in Urban and Regional Planning and made important contributions to research on nonmotorized transportation and

travel behavior. She is currently working as a transportation planner with Mn/DOT.

Outreach to pre-college students continues to expand, with new curriculum components and activities aimed at encouraging interest in transportation issues and building the skills necessary for success in higher education. The Gridlock Buster online traffic control game, developed by the MTO and launched last year, has proved exceedingly popular with secondary and post-secondary students, teaching principles of urban traffic management in a fun and interactive way.

I would like to take this opportunity to thank departing members of the ITS Institute Board for their contributions to our success. These include Major Mike Asleson of the Minnesota State Patrol; Sue Lodahl, Mn/DOT Assistant State Maintenance Engineer; Bob Winter, Mn/DOT District Operations Director; Tim Henkel, Mn/DOT Modal Planning and Program Management Director; Vincent Valdes, FTA Associate Administrator; and Mn/DOT Commissioner Tom Sorel.

Last but not least, I would also like to acknowledge Robert C. Johns, former director of the Center for Transportation Studies and chair of the ITS Institute Board, who left the University of Minnesota in October 2009 to become director of the USDOT's John A. Volpe National Transportation Systems Center. Since his appointment as CTS director in 2001, Bob's leadership and wise counsel contributed greatly to the success of the ITS Institute and all its activities.



Max Donath, Director  
ITS Institute

## ITS Institute Funding Sources

### Federal Partners

Research and Innovative  
Technology Administration  
Federal Transit Administration  
Federal Highway Administration  
National Highway Traffic Safety  
Administration  
National Science Foundation  
U.S. Department of Homeland  
Security  
U.S. Department of the Interior-  
National Park Service  
Strategic Highway Research  
Program 2  
National Institutes of Health

### Non-Federal Partners

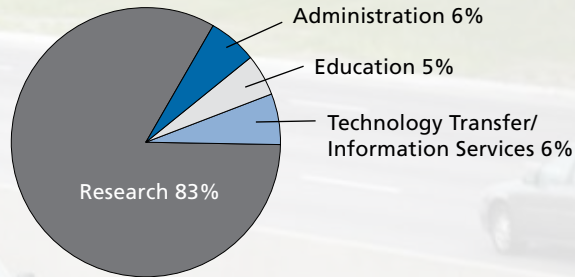
State of Minnesota  
Minnesota Department of  
Transportation  
University of Minnesota  
Twin Cities Metropolitan Council/  
Metro Transit  
Minnesota Valley Transit Authority  
Minnesota Local Road Research  
Board  
Local government agencies  
Business and industry  
Other state departments of  
transportation



## Financial Report

Expenditures for  
Year 11: July 1,  
2009–June 30, 2010

Total Expenditures:  
\$6 million



# OVERVIEW

## Mission Statement

The Intelligent Transportation Systems (ITS) Institute is a congressionally designated national University Transportation Center (UTC) funded through the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), the federal surface transportation bill passed in 2005. This funding continues the Institute's efforts initiated under SAFETEA-LU's predecessors, the Transportation Equity Act for the 21st Century (TEA-21) and the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA).

The ITS Institute plans and conducts activities that further the mission of the U. S. Department of Transportation's UTC program: to advance U.S. technology and expertise in the many disciplines that make up transportation through education, research, and technology transfer activities at university-based centers of excellence. To help us accomplish this, we direct the work of researchers from multiple disciplines to advance the state of the art in the core ITS technologies of computing, sensing, communications, and control systems to solve today's challenging transportation problems.

Our focus is on human-centered technology that enhances the safety and mobility of road- and transit-based transportation. To that end, we bring together technologists and those who study human behavior from the University with our partners—the U.S. Department of Transportation, Minnesota Department of Transportation, other government agencies, and private industry—to ensure that Institute-developed technologies become tools that help us understand and optimize human capabilities as they relate to transportation.

Additionally, the Institute addresses issues related to transportation in a northern climate, investigates technologies for improving the safety of travel in rural environments, and considers social and economic policy issues related to the use of core ITS technologies.

## Management Structure

The ITS Institute is located on the Twin Cities campus of the University of Minnesota and is housed within the Center for Transportation Studies (CTS), with additional facilities at the University's Duluth campus. Much of the Institute's successful leadership in the development and application of intelligent transportation systems and technologies results from its state and national partnerships, including those with CTS, the Minnesota Department of Transportation, transit agencies, private industry, and county and city engineers.

The Institute director leads its operation, implements its strategic plan, and assumes overall responsibility for its success. In this role, he directs Institute programs, personnel, and funds.

The Institute's board guides and oversees the implementation of the Institute's work. The board works with the director to ensure that the USDOT's Research and Innovative Technology Administration requirements are met, approves annual plans and budgets, and meets at least twice yearly to provide direction to, and approval of, the Institute's activities.

Institute staff and University researchers, drawing from various areas of expertise, help create and spread knowledge related to intelligent transportation systems through research, education, and technology transfer activities. In addition, the leadership and staff of CTS provide connections and access to an extensive transportation research and education network. The Institute's affiliation with the Center allows it to work seamlessly with CTS staff and benefit from its diverse outreach, administration, and communications capabilities.

### ITS Institute Board

The ITS Institute Board provides oversight and guidance to the Institute, overseeing the tactical implementation of program activities and the expenditure of funds.



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(Chair)  
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University of Minnesota



**Bernie Arseneau**  
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**Michael Baltes**  
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**Deb Bloom**  
City Engineer, Roseville,  
Minnesota



**Colonel Mark Dunaski**  
Chief, Minnesota State Patrol



**Mary Ellison**  
Deputy Commissioner,  
Minnesota Department of Public Safety



**Mark Hoisser**  
Executive Director, DARTS



**Tim Johnson**  
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**Sue Mulvihill**  
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**Joe Peters**  
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Melissa Stone  
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**Law School**  
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### **Northland Advanced Transportation Systems Research Laboratories**

The NATSRL program director is Eil Kwon. Support and guidance for NATSRL are provided by its advisory board and research advisory panel, whose members are staff from partnership agencies that include Mn/DOT, St. Louis County, and the City of Duluth.

Faculty and research staff conducting ITS-related research for NATSRL include the following:

University of Minnesota Duluth, Swenson  
College of Science and Engineering

**Chemistry and Biochemistry**  
John Evans  
Venkatram Mereddy

**Civil Engineering**  
Eil Kwon

**Computer Science**  
Peter Willemsen

**Electrical and Computer Engineering**  
M. Imran Hayee  
Taek Kwon  
Hua Tang  
Jiann-Shiou Yang

**Mechanical and Industrial Engineering**  
Seraphin Abou  
Hongyi Chen  
Ryan Rosandich  
Xun Yu  
Debao Zhou



# LABS AND FACILITIES

## Northland Advanced Transportation Systems Research Laboratories

[www.its.umn.edu/ProgramsLabs/NATSRL](http://www.its.umn.edu/ProgramsLabs/NATSRL)

### **Staff**

Eil Kwon, Director

### **Purpose**

The Northland Advanced Transportation Systems Research Laboratories (NATSRL), founded in 2000, pursue research in the areas of intelligent transportation systems (ITS) at the University of Minnesota Duluth (UMD). The primary mission of NATSRL is to develop innovative technologies that can be directly applicable in making the transportation systems in northern areas safe, efficient, and sustainable.

### **Research**

The research focus areas in NATSRL are:

- Advanced sensing technologies for detecting and measuring traffic, driver, pedestrian, and pavement condition
- Traffic and driver safety technologies through vehicle and infrastructure integration with wireless communication
- Winter road snow and ice management decision-support strategies
- Advanced traffic operations and management strategies under various traffic and weather conditions

### **Recent Projects**

- Carbon-nanotube-based intelligent concrete pavement for traffic detection
- A non-intrusive sensing system to detect driver drowsiness
- A snow and ice detection system for bridge decks and road surfaces with time domain reflectometry (TDR) technology

- Traffic detection and monitoring based on customized vision-processing hardware
- A realistic snow-rendering graphic simulation model that can be used to visualize and assess the effects of alternative snowplow truck lighting and coloration designs
- A dedicated short-range communications (DSRC)-based work-zone traveler information system
- A fuel-cell-based alternative power system for operating ITS devices
- A robotic painter for pavement marking
- An infrared thermal-camera-based deer detection system with automatic tracking
- A decision-support system for proactive deployment of ITS safety strategies
- A road-departure warning system with automatic identification of vehicle location

### ***Capabilities***

All research projects supported by NATSRL are performed in individual departments at the University of Minnesota Duluth, with a common facility that includes a driving simulator and an outdoor laboratory where new hardware for traffic, snow, and ice detection can be tested.

NATSRL has also been developing cooperative research activities in transportation with foreign research institutes and universities. These include a visiting researcher and graduate student exchange program and joint research projects. Currently one international graduate student and one faculty member are working at NATSRL as visiting scholars.

### ***Partners***

NATSRL has formed a strong partnership with its key stakeholders by developing a Research Advisory Panel (RAP) and Advisory Board structure whose membership includes experts from the following partnership agencies:

- U.S. Department of Transportation–Research and Innovative Technology Administration

- Minnesota Department of Transportation
- St. Louis County, Minnesota
- City of Duluth

The RAP, which meets every semester, plays a major role in managing and guiding NATSRL research activities as the ongoing communication channel between NATSRL faculty and local transportation practitioners. The strategic directions and the yearly research programs of NATSRL are discussed and finalized at an annual Advisory Board meeting.





## Intelligent Vehicles Laboratory

[www.ivlab.umn.edu](http://www.ivlab.umn.edu) | [www.bus2.me.umn.edu](http://www.bus2.me.umn.edu)

### Staff

Craig Shankwitz, Director  
Pi-Ming Cheng, Research Associate  
Eddie Arpin, Research Fellow  
Alec Gorjestani, Research Fellow  
Arvind Menon, Research Fellow  
Bryan Newstrom, Research Fellow  
Erin Kurshoff, Principal Accounts Specialist

### Purpose

The Intelligent Vehicles Laboratory (IV Lab) develops and tests innovative, human-centered technologies that improve the operational safety, mobility, and productivity of the transportation network in general, and highway vehicles in particular. These human-centered technologies integrate sensors, actuators, computer processors, and custom human interfaces to provide drivers with needed information under difficult driving conditions such as low visibility, severe weather, and narrow and congested roadways.

Although the IV Lab is focused primarily on vehicles, it also considers the roadway, supporting infrastructure, and electronic wireless communication as part of the transportation network and uses all of these elements in generating solutions to transportation problems.

### Research

The University of Minnesota is recognized as a leader in developing and testing driver-assistive systems and is one of a small number of universities nationwide conducting this work. Current research topics include the design and testing of custom human interfaces, technologies to assist and monitor inexperienced teen drivers, collision-avoidance sensors and algorithms, intersection surveillance systems, and wireless communication (vehicle-vehicle and vehicle-infrastructure).

### Recent Projects

- Advanced Bus Rapid Transit: Innovative Technologies for Dedicated Roadways
- Infrared Sensing for Driver-Assistive Systems
- Multiuse, High-Accuracy, High-Density Geospatial Databases
- In-Vehicle Driver Assistance for Teenagers
- Motorcycle Riding Impairment at Different BAC Levels
- Guidance Augmentation for Transit Applications
- GPS Augmentation for Robust Lane Assistance
- Analysis of Highway Design and Geometric Effects on Crashes

### Capabilities

IV Lab research focuses on increasing driver safety in difficult driving conditions through the use of vehicle-guidance and collision-avoidance technologies. Several vehicles serve as experimental testbeds for these technologies, including two passenger cars, the SAFEFLOW (an International 2540 crew-cab snowplow), a state highway patrol car, and a Minnesota Valley Transit Authority (MVTA) bus used for transit research. Using these vehicles, IV Lab researchers are developing, testing, and integrating advanced technologies, including:

*A system designed to reduce rural intersection crashes by predicting gaps in oncoming cross-traffic was activated on January 20, 2010, at the intersection of U.S. 52 and Goodhue County Route 9 in southwestern Minnesota. (See p. 22 for more on this research.)*



- Centimeter-level differential global positioning systems (DGPS)
- High-accuracy digital-mapping systems
- Range sensors, including radar and laser-based sensors
- A head-up display (HUD), virtual rear-view mirror, and other graphical displays
- Haptic and tactile feedback

The IV Lab's partnership with the Minnesota Department of Transportation provides access to roads and other infrastructure, including the Minnesota Road Research Project (MnROAD) test track, which consists of a freeway and a low-volume road pavement test track with 40 different road material test sections, 4,500 electronic sensors, a weigh-in-motion scale, a weather station, and DGPS correction signals.

The core staff of the IV Lab consists of engineering professionals who work closely with an interdisciplinary team of specialists, including cognitive psychologists specializing in human factors from the ITS Institute's HumanFIRST Program. The staff has developed expertise in wireless communications, embedded computing, visibility measurement and quantification, geospatial databases, virtual environments, image processing, driver-assistive technologies, control systems, and sensors.

### Deployment

Four vehicles with driver-assistive technology have been deployed in Alaska, where high snowfall rates and blowing snow routinely cause whiteout conditions and zero visibility. Because of its success with the IV Lab, the state of Alaska has ordered three new driver-assistive systems and two upgrade kits for its systems that operate near Valdez. The kits will provide new computation capability not provided by the current computers.

The Minnesota Mobile Intersection Surveillance System (MMISS), developed under the auspices of the IV Lab's rural intersection crash reduction research program, has collected data on driver behavior at rural

expressway through-stop intersections in Wisconsin, Iowa, Michigan, North Carolina, Georgia, Nevada, and California. Data collection in a broad array of states supports the development of a nationally deployable intersection safety system designed to save lives among rural drivers. This technology is also being deployed at a rural expressway intersection (U.S. 53 and County 77 in Minong, Wis.) through the USDOT's Rural Safety Improvement Program (RSIP).

### Partners

- U.S. Department of Transportation
  - Federal Highway Administration
  - Federal Transit Administration
  - Research and Innovative Technology Administration
- Minnesota Department of Transportation
- Minnesota Local Road Research Board
- Hennepin County
- Minnesota Valley Transit Authority
- Twin Cities Metro Transit
- Other local and regional agencies

*Technology developed by the IV Lab will help bus drivers maintain reliable schedules while operating safely on narrow bus-only highway shoulders. A fleet of 10 buses equipped with the driver-assistive technology will go into service in the Twin Cities in 2010.*



## Minnesota Traffic Observatory

[www.mto.umn.edu](http://www.mto.umn.edu)

### Staff

John Hourdos, Director

Ted Morris, Manager

Chen-Fu Liao, Educational Systems Manager

### Purpose

The Minnesota Traffic Observatory (MTO), a joint effort of the ITS Institute and the Department of Civil Engineering, supports a wide range of research in monitoring, management, and simulation of traffic systems. The observatory combines real-time traffic data with state-of-the-art simulation systems, giving researchers and engineers the ability to analyze existing conditions and compare real-world observations with the results of simulated conditions.

*MTO manager Ted Morris helps a visitor experience the facility's Digital Immersive Environment.*



### Research

MTO research focuses on testing and evaluating new transportation management and operational strategies and traveler information technologies. Specific focus areas include microscopic simulation, traffic model calibration, and incident detection and prevention.

### Recent Projects

- A Predictive Study of Use Impacts on the Denali Park Road
- Bus Signal Priority Based on GPS and Wireless Communications
- Enhanced Micro-Simulation Models for Accurate Safety Assessment
- Identification and Simulation of Common Freeway Accident Mechanisms
- Accident Prevention Based on Automatic Detection of Accident Prone Traffic Conditions
- Evaluation and Improvement of the Stratified Ramp Metering Algorithm through Microscopic Simulation

### Capabilities

The MTO offers researchers the ability to study large traffic systems where many different parts interact. Video feeds flow into the observatory from an extensive network of traffic cameras. The observatory is connected by fiber-optic lines to the Minnesota Department of Transportation's Regional Traffic Management Center, allowing the MTO to capture up to 16 live feeds at a time from the 400 cameras the agency uses to monitor the metropolitan freeway system. In addition, the observatory operates a dedicated system of cameras overlooking the I-94/I-35W Commons interchange in Minneapolis—turning one of the most crash-prone intersection areas in the state into a real-world laboratory for the study of traffic flows and vehicle crashes.

The availability of a wealth of high-quality video



data is ideal for the use of machine-vision systems to monitor and categorize vehicle movements. Computer image-processing algorithms developed by University of Minnesota researchers enable the observatory to track and analyze complex traffic patterns at intersections, on freeway interchanges, and in other areas that are difficult to study using other data sources.

Another key component of the MTO is a virtual traffic control center and simulation lab. Interfacing traffic signal control hardware with realistic traffic network models creates a powerful hardware-in-loop simulation tool for examining system performance under a variety of conditions.

Several traffic simulation packages are used in the MTO, primarily AIMSUN-NG for “microscopic” simulation based on individual vehicles, and the KRONOS 9 package, developed at the University of Minnesota, for macroscopic (platoon-based) simulations.

Given the complexity of the traffic issues that the observatory is designed to study, robust visualization tools are critical. In addition to a large projection wall, two innovative pieces of equipment provide researchers with powerful interactive visualization capabilities.

The GIS/MAP table combines the large horizontal working surface of a traditional drafting table with the interactive capabilities of geographic information systems technology. Two ceiling-mounted digital projectors create a seamless image covering the entire conference-table-sized surface, which can be manipulated using a tabletop pointing device to pan and zoom in on specific areas. In contrast to traditional ways of viewing digital maps and models on a desktop monitor, the table allows users to comfortably survey the entirety of a large traffic system and quickly focus in on areas of interest.

The DEN (Digital Immersive ENvironment) is a high-fidelity 3D interactive immersive display system that allows researchers to observe and explore traffic flow scenarios within any environmental context and from any fixed or moving perspective. Three sides of the cubical structure are formed by large rear-projection screens presenting

polarized images from two slightly different sources; a user wearing specially designed glasses sees a different image with each eye, producing a realistic sense of three-dimensional space. A tracking system mounted in the DEN’s ceiling monitors the position of the user’s head and adjusts each projector to provide an accurate perspective.

### ***Outreach and Education***

The MTO is dedicated to supporting transportation education at the University. MTO facilities are used by faculty and students in civil, mechanical, and electrical engineering, computer science, and affiliated disciplines, and MTO staff work with faculty to develop interactive laboratory modules that help students understand advanced topics in traffic management. The MTO also hosts training events for transportation professionals, covering topics such as the effective use of traffic simulations for capacity analysis and planning.

### ***Partners***

- U.S. Department of Transportation
  - Federal Highway Administration
  - Research and Innovation Technology Administration
- Minnesota Department of Transportation
- University of Vermont
- National Park Service
- Next Generation SIMulation (NGSIM) Community
- Other local and regional agencies



*Visitors view the MTO’s GIS/MAP table with lab director John Hourdos (far right).*

## HumanFIRST Program

[www.humanfirst.umn.edu](http://www.humanfirst.umn.edu)

### Staff

Michael Manser, Director  
Ensar Becic, Research Associate  
Janet Creaser, Research Fellow  
Peter Easterlund, Simulator Manager  
Justin Graving, Research Fellow

### Purpose

The Human Factors Interdisciplinary Research in Simulation and Transportation (HumanFIRST) Program applies human factors principles to improve scientific understanding of driver behavior and supports the design and evaluation of usable intelligent transportation systems.

### Research

As implied by its name, the program's research strategy is based on a driver-centered approach, considering the "human first" within the transportation system. Research seeks to propose, design, and evaluate innovative methods

to improve transportation safety based on a scientific understanding of driver performance and the psychological processes associated with traffic crashes. It considers how a driver will accept and use a proposed system while also considering the possibility of its producing undesirable driver responses and adaptation (e.g., distraction, complacency, fatigue, risk-taking) that could undermine the system goal of improved safety. Specific research topics include:

- Driver distraction from in-vehicle tasks and cell phones
- Driver-assistive systems to reduce teen-driver-related fatal crashes
- Rural and urban driver attitudes and crash risk
- Interventions for crash reduction at rural intersections
- Intelligent driver-support technologies such as vision-enhancement, collision-avoidance, hazard-awareness, and lane-keeping systems for passenger and special-purpose vehicles
- Alcohol impairment, including motorcycle safety

### Recent Projects

- Smartphone-Based Novice Teenage Driver Support System
- Vehicle-Based Teen Driver Support Systems
- Rural Intersection Decision Support
- CICAS Stop Sign Assist (SSA) System
- Effects on Driver Performance of Advanced Traveler Information Systems and 511 Information Retrieval
- Motorcycle Riding Impairment at Different BAC (Blood Alcohol Concentration) Levels
- Generational Perspectives on Teen and Older Drivers on Traffic Safety in Rural and Urban Communities
- The Use of Video Feedback in Urban Teen Driving

*A new bus driving simulator installed at the Minnesota Valley Transit Authority garage allows program staff to test and evaluate bus driver-support systems and bus driver training protocols.*



### Capabilities

The centerpiece of the facility is a state-of-the-art driving simulator engineered specifically for human factors research in surface transportation. This versatile simulator consists of a full-cab Saturn SC2 vehicle and software capable of creating virtual environments that precisely reproduce any geospecific location. In addition, specialized visual-effect software can produce realistic weather and lighting—including light and shadow that correspond with season and time of day—as well as vehicle headlights with nighttime glare and water reflections.

The visual environment is generated with high-resolution images (1.97 arcmin per pixel) over a wide field of view (FOV): 210-degree forward field of view, 50-degree rear FOV, and two 20-degree FOV side mirror images. This immersive driving experience is enhanced by realistic motion generated by a three-axis motion base and both high- and low-frequency vibration units, including a surround-sound system. With multiple sound systems, configurable touch panel displays (including head-up displays), haptic feedback through the seat and accelerator pedal, and a head-free eye-tracker that can detect in real time what a driver is looking at, this simulator supports the investigation of a wide range of interface options for ITS development, design, and assessment. These features make it one of the premier driving simulators in North America and Europe.

The HumanFIRST Program also has access to a new bus driving simulator installed at the Minnesota Valley Transit Authority garage, where program staff can test and evaluate bus driver-support systems and bus driver training protocols. Additionally, for real-world testing and validation, the program has access to a variety of test track and operational research settings in which participants can drive the program's fleet vehicles in a wide range of normal driving situations.

The HumanFIRST facility includes equipment for basic research on driver psychological functioning including a vision tester, DOT-certified breath alcohol analyzer, mobile psychophysiological recording system, mobile

eye-tracking system, video editing and behavior analysis suite, and a comprehensive psychometric test battery validated for traffic psychology. A strength of this equipment is that it can be employed in the driving simulator, test track, or on-road research facilities.

The program's core staff of transportation research specialists, made up of psychologists and engineers, provides a well-established base of content expertise. This core group is linked to a broad interdisciplinary network of experts in advanced, basic, and applied sciences throughout the University to provide a flexible and comprehensive research capacity. This network is supported by affiliations with additional University research units, which allows the program to create interdisciplinary teams to investigate a range of complex human factors research issues in transportation safety.

The program has close relationships with the Minnesota Departments of Transportation and Public Safety, private industry, traffic engineering consultants, and other related entities. These connections provide support for implementing research that will influence transportation policy in response to real-world problems both regionally and nationally. In addition, to ensure that research takes into account developments on the world stage, the program's work is supported by international collaborations with experts in relevant disciplines.

### Partners

- United States Department of Transportation
  - Federal Highway Administration
  - National Highway Traffic Safety Administration
  - Research and Innovative Technology Administration
- Minnesota Department of Transportation
- Minnesota Local Road Research Board
- Minnesota Valley Transit Authority
- Other local and regional agencies



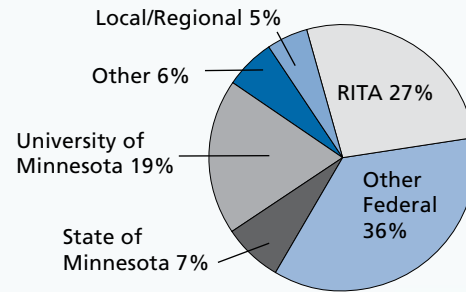
*Simulated view of the I-35W corridor in which buses outfitted with driver-assistive technology will operate. The simulator is being used to train MVTA bus drivers in using the technology to safely operate in the narrow bus-only shoulder lane.*



### Research funding sources for all ITS-related research projects

The total funding for ITS-related projects was approximately \$11.1 million in FY10. Sources for projects receiving funding in FY10 are shown in the chart to the right.

During this period, 52 faculty and research staff and 88 students were involved in ITS-related research.



## RESEARCH

ITS Institute research is centered on safety-critical technologies and systems for efficiently moving people and goods in the following areas:

- Human performance and behavior
- Technologies for modeling, managing, and operating transportation systems
- Computing, sensing, communications, and control systems
- Social and economic policy issues related to ITS technologies

The Institute's research program joins technologists—for example, engineers and computer scientists—with those who study human behavior to ensure that new technologies adapt to human capabilities, rather than requiring drivers to adapt to technology.

The Institute's geographic location gives it a unique advantage for developing research applicable to transportation in a northern climate and transportation in rural environments in addition to the metropolitan Twin Cities area. The ITS Institute research program includes research projects funded by various partners, including federal funds from the USDOT Research and Innovative Technology Administration's University Transportation Center program, the Federal Highway Administration, the Federal Transit Administration, the National Highway Traffic Safety Administration, the National Park Service, and the Department of Homeland Security. Other funding partners include the Minnesota Department of Transportation (Mn/DOT), Minnesota Local Road Research Board, Metropolitan Council, Hennepin County, Metro Transit, and the Minnesota Valley Transit Authority in addition to local governments, agencies, and private companies that contribute funding and in-kind match.

Activities undertaken by the Institute support all ITS-related research projects, regardless of funding source; all current ITS-related projects are listed in this annual report. The research section comprises two parts. The first highlights in detail a selection of projects under way, while the second lists all Institute projects either recently completed, in progress, or selected to begin this coming year.



## Research: Human Performance and Behavior

### Fuel Economy Driver Interfaces: Develop Interface Recommendations

There's more to vehicle fuel economy than an efficient engine and an aerodynamic body. How drivers choose to operate their vehicles can have a significant effect on fuel consumption.

HumanFIRST researchers are developing interface technologies to show drivers how their driving style is affecting fuel economy in real time. HumanFIRST director Mike Manser, who led the project, and researchers Mick Rakauskas (formerly with the University), Justin Graving, and James Jenness (a collaborator from collaborating organization Westat) recently evaluated a variety of fuel efficiency driver interface concepts, or FEDICs, to identify the most effective ways to display fuel economy information to drivers while they are behind the wheel. The HumanFIRST research is a portion of a larger study of FEDIC designs sponsored by the U.S. Department of Transportation's National Highway Traffic Safety Administration.

#### ***The smoother the better***

Research suggests that smooth driving practices—staying below the posted speed limit, avoiding aggressive acceleration, remaining alert to changes in traffic conditions in order to avoid large changes in speed—can reduce overall fuel consumption by as much as 15 percent. But while such a reduction represents a significant savings in fuel costs over time, drivers may not appreciate the benefits of changing their driving style if they cannot connect them to specific behaviors while they are driving.

With drivers more concerned than ever about saving fuel, a number of fuel efficiency display designs have appeared on the market in recent years. Some are standard equipment on certain automobile models; others are available as aftermarket add-ons. The absence of generally accepted or scientifically validated design standards for these devices has led to a wide variety of designs, many of which are quite visually complex.

A key objective of the HumanFIRST research was to

identify design elements that are informative to the driver but not so complicated that they contribute to driver distraction—a significant safety hazard.

The interface study consisted of three components: a comparative rating activity designed to determine how well each FEDIC design met the needs of users and conformed to principles of good user interface design; usability testing to identify the most useful components and design approaches; and testing in the HumanFIRST Program's immersive virtual driving simulator to examine the effectiveness of FEDIC concepts in realistic driving scenarios.

#### ***Testing and results***

During comparative rating of the display concepts, the researchers found that user needs were satisfied by simple interfaces that combined multiple types of information—for example, showing fuel economy in different ways, or displaying the effects of behaviors (such as acceleration) that affect fuel economy. Although the performance of the various FEDICs was largely similar, the designs differed markedly at the component level.

This finding led the researchers to focus the second phase of the study on examining individual components of FEDIC designs. In these tests, results show that representative or symbolic displays such as bars or icons were more usable than text-based displays; however, the researchers concluded that textual displays could still be



Michael Manser

*An in-vehicle field-operational version of the acceleration display developed based on the simulator study. Researchers added the color-changing leaf, which appears brown, blue, or green to indicate poor, average, or better-than-average trip fuel economy. As in the simulator study, this display shows acceleration relative to instant fuel economy. High mpg is indicated when the white bar is close to the white band in the center.*





valuable if they help users understand fuel economy.

Moving into the driving simulator, the HumanFIRST researchers tested a pair of alternative FEDIC designs under typical driving conditions. One interface concept displayed information about fuel economy, while the other displayed information about driver behaviors associated with fuel economy. In this test, the display of fuel economy information was more effective than the behavioral display in improving fuel economy. Data from participants driving with both displays indicated performance

was similar to a control group who were instructed to drive efficiently without a fuel economy display.

Overall, the study results suggest that fuel efficiency displays based on graphical representations augmented by textual information are likely to be effective and easy to use. Combining real-time and long-term information also appears to be an effective strategy. Keeping the display visually simple is an important consideration, both to improve the readability and effectiveness of the display and to avoid distracting the driver.

### Comparison of Dual-Phase and Static Signage



*Kathleen Harder*

As many as 25,000 drivers a year end up at the wrong terminal at Minneapolis-St. Paul International Airport, sometimes missing their flights.

To reduce the confusion, the Metropolitan Airport Commission renamed the airport's Lindbergh and Humphrey terminals as Terminal 1 and 2 and put up signs with the new names this spring. Simultaneously, a research team from the University conducted a study to find out whether conventional or electronic signs were

more effective in helping drivers arrive at the correct terminal.

The study, led by Kathleen Harder, director of the University's Center for Design in Health, found that drivers responded well to both conventional and changeable message signs (CMSs) if the signs included airline information. Harder's study also added to research that found older drivers drive more slowly and make more mistakes when responding to highway signs.





### **Unique airport**

The Twin Cities airport has 14 airlines split between two terminals, with 9 airlines at the larger Terminal 1 and 5 airlines at the smaller Terminal 2. The airport is unique in the United States in that its two terminals are separated by different freeway exits. That forces drivers to make split-second decisions about where to exit for their airline.

“The challenge is to devise a format to present information so drivers can deal with it in a timely way,” Harder said.

In the University study, 120 licensed drivers from the Twin Cities used a simulator to take two trips on a trunk highway approaching the airport. Participants were randomly assigned to either changeable signs that cycled the names of airlines or three static message signs and had to pick the correct airline.

Participants chose the correct exits for 215 of the 240 trips. Of the drivers who picked the wrong exit, 20 of the misses occurred on the first drive and five on the second drive, showing that the drivers had a quick learning curve. “That’s fine for repeat visitors to the Twin Cities,” Harder said. “The question is, what do you do with first-timers in terms of signage?”

The high success rate of drivers masked some differences in driver reactions. Older drivers had more than three times the mistakes of the youngest group of drivers. And they drove almost five miles per hour slower than the younger drivers.

Harder found similar age-related differences in two previous studies she helped conduct on changeable message signs—one on how drivers respond to traffic directions, the other on driver response to an Amber Alert sign. That’s a problem that will get worse as the population ages, she said.

### **Better-designed signs**

The study found no statistically significant difference in the number of driver mistakes based on the type of sign—11 mistakes were made with the CMSs and 14 with the static signs. But Harder helped the Minnesota



*Research results helped inform design changes made to highway signs, such as alphabetizing and centering airline names to help drivers scan information quickly.*

Department of Transportation make a number of design changes on its new static signs, which include airline names for Terminals 1 and 2. Her suggestions include alphabetizing and centering the airline names to help drivers scan the information more quickly.

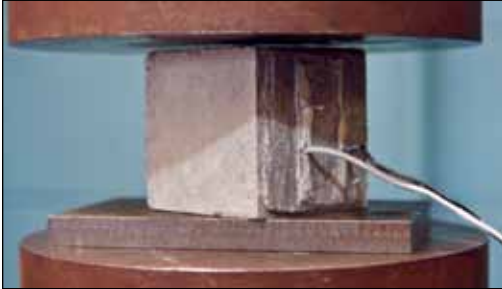
Cassandra Isakson, assistant state traffic engineer for Mn/DOT, which sponsored the project, said she was encouraged by the study’s finding that most drivers needed only one sign to pick the right terminal.

The airport is likely to expand in the future, with Humphrey, or Terminal 2, slated to take as much as half of the airport’s driver traffic, she said.

“Today there’s room on the corridor for three signs. But as the airport starts to grow, [it] might end up with 20 or 30 airlines,” she said. “We needed to investigate this issue for the possibility of future growth. We needed to know motorists had the ability to get the terminal information from one CMS as needs changed.”

## Research: Computing, Sensing, Communications, and Control Systems

### Carbon Nanotube-Based Self-Sensing Concrete for Pavement Structural Health Monitoring and Traffic Flow Detection



*Concrete containing embedded carbon nanotubes for stress-level sensing*

Engineers have been intrigued by the properties of carbon nanotubes since they were discovered nearly 20 years ago. Now University of Minnesota researchers, with funding from the ITS Institute, are putting the cylindrical carbon molecules to work in a new role: creating advanced paving materials for tomorrow's smarter roads.

Xun Yu, assistant professor of mechanical and industrial engineering at the University's Duluth campus, is working with UMD director of transportation research programs Eil Kwon and research associate Baoguo Han to develop a new type of traffic sensor that relies on the electromechanical properties of carbon nanotubes incorporated into concrete pavements.

Carbon nanotubes (CNTs) are cylindrical molecules in which carbon atoms are organized into hollow cylinders only a few atoms in diameter but up to millions of atoms long. In addition to being extremely strong, carbon nanotubes are electrical semiconductors that exhibit linear changes in electrical resistance in response to mechanical stress, a quality known as piezoresistance.

Yu's research aims to put piezoresistance to work by mixing CNTs with cement. In a well-formulated CNT/

cement composite, evenly distributed nanotubes would form a web of carbon filaments spanning the entire paved area. Installing a simple set of electrodes to measure electrical resistance would turn the pavement into a single large pressure sensor.

Such pavements could even monitor their own health. Because the piezoresistive properties of a CNT network depend on the mechanical

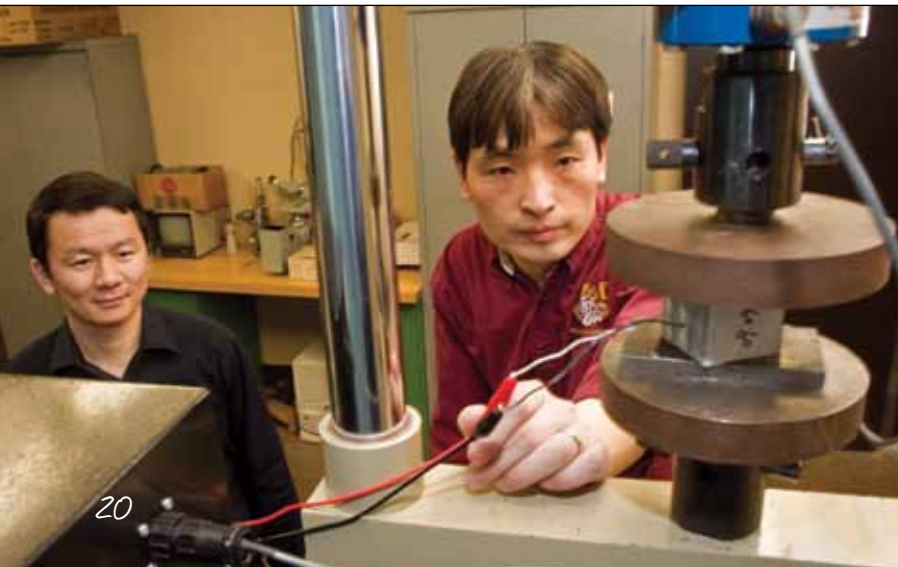
stress within the CNT/cement composite, the response of a composite pavement will change when cracking occurs. This self-monitoring would enable transportation agencies to quickly detect and respond to pavement damage, as well as track the condition of their pavement infrastructure assets.

With no moving parts or complex electrical circuits, the composite pavement design is mechanically simple, and therefore immune to many types of damage that cause failures in more complicated sensor systems such as pavement-embedded inductive loop detectors. A properly formulated CNT/cement composite could be installed much like traditional concrete pavement and would be resistant to mechanical damage. Indeed, the high strength of carbon nanotubes could reinforce the pavement, making it more wear-resistant than standard concrete.

However, fabricating CNT/cement composites that can perform effectively as sensors is far more challenging than pouring a cupful of nanotubes into a cement mixer. CNTs tend to clump together when placed in solution, forming discrete blobs rather than the even, continuous network that piezoresistive sensing requires. To overcome this tendency, Yu is studying different chemical methods of encouraging CNTs to disperse, with an eye toward identifying methods that can be incorporated into commercial concrete mixing processes.

In addition to developing a manufacturing process for CNT/cement composites, Yu's sensor concept also depends on developing a thorough understanding of the electrical and mechanical properties of CNTs. In the laboratory, Yu is currently investigating composites' piezoresistive response to dynamic and static stresses as well as the effects of temperature, humidity, and other environmental factors. Yu's research has also recently been extended as a result of funding from the National Science Foundation and the Federal Highway Administration.

*Research associate Baoguo Han and Xun Yu*



## Automated Vehicle Location, Friction Measurement, and Applicator Control for Winter Road Maintenance

Each winter, Minnesota uses an estimated 200 pounds of sand and salt per person to deice roads and keep them safe for travel. Deciding just where to apply the salt and sand mixture is the job of the state's snowplow drivers—that's in addition to directing the blade, clearing the snow, and driving in adverse weather conditions.



*Rajesh Rajamani*

But the drivers' job could become a lot easier thanks to an automated deicing system developed by mechanical engineering professor Rajesh Rajamani and colleagues Lee Alexander and Gurkan Erdogan for a research project funded by the Minnesota Department of Transportation (Mn/DOT). (Previous phases of this research were funded by the ITS Institute.)

The system relies on a sensor attached to a small wheel mounted near the front axle of the snowplow. The sensor wheel is mounted at a slight angle to the snowplow's direction of travel, causing it to receive a constant lateral force as the plow moves forward. When the snowplow passes over icy pavement, the sensor wheel slips more easily and experiences less lateral force, indicating a proportional drop in the tire-road friction coefficient. Data on the amount of lateral force against the sensor wheel are continually sent to an onboard data processor, which calculates the friction coefficient and signals the deicer applicator to release sand and salt as the rear of the plow passes over the slippery area a quarter of a second later.

One of the most difficult challenges the team faced in designing the system is that data from the sensor wheel contains a lot of "noise" caused by oscillations in the body of the snowplow and irregularities in the road surface. Normal steering and acceleration cause additional variations in the signal from the sensor wheel. The researchers developed a set of sophisticated filtering

algorithms to deal with these factors, enabling the system to accurately determine the friction coefficient under real-world operating conditions.

According to Rajamani, the new system is reliable, has few moving parts, and is inexpensive to build; the total cost of the components is less than \$1,500. "This system reduces the burden on drivers because it relieves them of controlling the applicator, deciding when to sand, and determining what the rate of sanding should be," Rajamani said.

The system also reduces unnecessary use of salt and sand because it targets only icy spots on the road. This saves money and limits environmental damage caused by the overuse of chemicals. In addition, the system employs GPS technology that collects quantitative data that could be used both to identify areas likely to become slippery and to inform the general public about winter road conditions.

In April, the deicing system received the Research Partnership Award from the Center for Transportation Studies [see page 45]. The system has also been featured on KSTP-TV, in the *Minnesota Daily* (the University of Minnesota's campus newspaper), and as a lead news item on the University of Minnesota Web site.

The researchers are confident the deicing system will soon be ready to roll on Minnesota's streets and highways. "We are hoping that this technology will be evaluated by Mn/DOT supervisors and snowplow drivers on two or three snowplows during the next year," Rajamani said.



*A sensor is attached to a small wheel mounted near the front axle of the snowplow.*

*The system reduces unnecessary use of salt and sand because it targets only icy spots on the road.*





## Research: Technologies for Modeling, Managing, and Operating Transportation Systems

### Cooperative Intersection Collision Avoidance Systems – Stop Sign Assist System



Researchers Alec Gorjestani and Arvind Menon

A car traveling along a rural road stops at an intersection with a divided highway. The driver waits for a gap in traffic on the highway, then moves forward into the intersection to merge with highway traffic. But the driver has made a dangerous miscalculation, and the car is struck by an oncoming vehicle that closed the gap too quickly.

This scenario plays out every day on rural roads throughout the United States, often with fatal results. Recent research has shown that driver miscalculation, or unsafe gap acceptance, rather than issues such as stop sign violations, is the key factor contributing to crashes at unsignalized rural through-stop intersections.

But a groundbreaking system now being field-tested could reduce the number of such crashes by giving drivers reliable, accurate information about approaching traffic. The system, developed by researchers from the ITS Institute's Intelligent Vehicles Laboratory (IV Lab) and HumanFIRST Program in cooperation with the Minnesota Department of Transportation, uses multiple

sensors and advanced computer algorithms to track vehicles moving along a rural divided highway.

The Cooperative Intersection Collision Avoidance Systems–Stop Sign Assist (CICAS-SSA) system warns drivers stopped on a secondary rural road when gaps in the highway traffic are too small to allow entry or cross safely. On the active LED icon-based sign, a yellow rectangle indicates an approaching vehicle, and a red circle and red rectangle warn that the vehicle poses a threat to drivers preparing to cross or merge.

Key players in this interdisciplinary project are Craig Shankwitz, director of the IV Lab, and researchers Arvind Menon and Alec Gorjestani. Also collaborating is Mike Manser, director of the HumanFIRST Program, along with researchers Janet Creaser, Justin Graving, and Ensar Becic. ITS Institute director Max Donath is the principal investigator.

If the CICAS-SSA system works well, costly reconstruction of dangerous intersections could be avoided. The system is economical: the cost of the SSA system is about the same as that of a four-way stop light, but unlike the stop light, the system doesn't decrease the capacity of the expressway. The cost of a sign (there are four per intersection) might be reduced by designing a custom version once the system has proven successful at reducing crashes at these intersections.

A three-year field test of the CICAS-SSA system began in January 2010 when the first system was activated at the intersection of U.S. Highway 52 and County State Aid Highway (CSAH) 9 in Goodhue County near Cannon Falls, Minnesota. This intersection was chosen because a statewide analysis of through-stop expressway intersections showed it had a history of serious crashes and fatalities—for which unsafe gap acceptance was a key contributing factor.

A second SSA system was activated in April 2010 in

The intersection of U.S. 53 and Wis. Hwy. 77 near Minong, Wisconsin



Washburn County, Wisconsin, at the intersection of U.S. 53 and Wis. Hwy. 77, about 40 miles south of Spooner. This intersection also has a history of serious crashes.

This fall, two more systems will be activated: the first on Minn. Hwy. 23 at CSAH 7 in Lyon County near Marshall, Minnesota, and the second on U.S. 169 at CSAH 11 in Milaca County. During the three-year period from 2006 to 2008, an average of four right-angle crashes per year have occurred at each of these two intersections.

The CICAS-SSA field test will follow three tracks. The first track—implemented at the Goodhue County, Minnesota, and Washburn County, Wisconsin, sites—consists of continuous data collection for all traffic passing through the intersection on both the major and minor roads. These data will be subjected to a “macroscopic” analysis to determine whether the SSA system helps drivers reject smaller gaps and accept larger ones. If so, this will mean that drivers are making better decisions at the intersections, which should reduce the number of crashes.

In the second track, which will be implemented at the Lyon County intersection, instrumentation will be installed in the vehicles of 30 drivers who normally pass through the intersection. Data collected by the instrumentation will be subjected to a “microscopic” analysis of driver behavior. This analysis will quantify both how drivers respond to the CICAS-SSA system, and whether the system leads drivers to accept safer gaps over time.

The third track, implemented at the Milaca County intersection, will simply monitor the intersection to verify whether there is a reduction in crashes due to the CICAS-SSA deployment.

Although field-testing is still in the preliminary stages, the early results are promising. At the Goodhue County intersection, one crash occurred during the seven months from February through July 2010; normally there would be an average of six per year. At the Washburn County intersection, no crashes occurred in



*The intersection of U.S. 52 and Goodhue County Route 9 in southwestern Minnesota*

the four months from April through July 2010. This is especially significant as that intersection is located in an area of Wisconsin that is heavily traveled during the spring and summer.

Over the course of the field test, the research team will determine whether driver decision making and behavior change over time as a result of learning, familiarity, or satisfaction with the CICAS-SSA system. If drivers learn to make better decisions (that is, if they learn to cross or merge only when the gap is safe), crash rates may drop for nearby intersections as well, not merely those at which the CICAS-SSA system is deployed.

[More information about rural unsignalized intersection research can be found at [www.its.umn.edu/Research/FeaturedStudies/intersections/index.html](http://www.its.umn.edu/Research/FeaturedStudies/intersections/index.html).]



*Results of the research could be applied to freight planning issues such as measuring truck travel-time reliability and the impact of congestion on the cost of freight movement.*

## Using Archived Truck GPS Data for Freight Performance Analysis on Interstate I-94/I-90 from the Twin Cities to Chicago

The I-94/I-90 freeway corridor between the Minneapolis-St. Paul metropolitan area and Chicago is one of the most important links for freight traffic in the Upper Midwest, and freight traffic on the route is steadily increasing. To help the Minnesota Department of Transportation (Mn/DOT) better understand freight movements along this key corridor, Chen-Fu Liao, senior systems engineer with the Minnesota Traffic Observatory, evaluated data from the national Freight Performance Measure (FPM) system. Liao worked with John Tompkins, project manager with Mn/DOT's Office of Freight and Commercial Vehicle Operations, who helped coordinate the data from Wisconsin and Illinois. The research was sponsored by Mn/DOT.

The Freight Performance Measure system is a collaborative effort of the Federal Highway Administration and the American Transportation Research Institute (ATRI).

Since 2002, the system has collected data from automatic vehicle location (AVL) units and cellular/wireless communication systems installed on commercial vehicles in order to measure freight movements along the interstate highway system. Currently, the system has the ability to derive average truck travel speed and travel time on all national highways.

Liao's research is an effort to extend the utility of the FPM system by deriving new performance measures from the data collected. Understanding how traffic volumes affect the reliability of shipping times between major commercial centers, for example, will be useful to logistics planners who need to estimate how long it will take to move goods from place to place.

The ATRI receives more than two billion data points every year, and the amount of data is expected to double in just a few years. Liao's research addressed the need to develop efficient techniques for turning this huge volume of data into usable information.

Liao's research analyzed data on heavy trucks (mainly commercial Class 8 vehicles weighing over 20,000 pounds). Using statistical software, he processed data on truck trips along the corridor from May 2008 to April 2009, including truck speed, speed variation, truck volume variation, distribution of destinations, stop location, and rest duration. Based on this data, Liao developed methods to measure the level of congestion and travel-time reliability along the corridor.

Results from the FPM analysis could be applied to a number of freight planning issues, Liao says, including measuring truck travel-time reliability and the impact of congestion on the cost of freight, determining where truck stops or parking facilities are needed, and evaluating how traffic volume affects cars and trucks differently.

*Mn/DOT's John Tompkins and Institute researcher Chen-Fu Liao*





## Development of Algorithms for Travel-Time-Based Traffic Signal Timing

Anyone who has waited a long time at a red light on a busy road knows how challenging it is for traffic planners to get the signal timing right.

The timing patterns of current traffic signals use data from historical loop-detector traffic counts. These data don't take into account daily traffic fluctuations based on crashes, seasonal patterns, bottlenecks at other upstream or downstream intersections, or other factors that can influence driver decisions.

But researchers at the University of Minnesota are working on a new method that would feed real-time traffic data into signals on arterial roads. Their aim is to capture data from the increasing number of vehicles that have GPS equipment and the ability to communicate their location.

"We envision that in the future, cars will have a communication mechanism," said Henry Liu, assistant professor in the Department of Civil Engineering, who is leading the research sponsored by the ITS Institute. "Cars will be able to talk to the intersection controller and talk to each other to communicate their speed and location on a link."

To use the new data, Liu and his team developed a model that could incorporate both the real-time GPS data, which include the speed and trajectory of individual vehicles, with loop-detector data on traffic volumes.

"The important thing is the technology is now available to track vehicles over a short segment to allow us to determine their location and speed at a certain point," Liu said. "We're looking at how these new data can help us develop better signal timing." Their work is one of the first attempts to estimate traffic flows on an arterial road with traffic signals using the in-pavement detector and GPS data.

To create their new traffic models, Liu's team faced several challenges. The first was the unpredictable nature of traffic at signalized intersections. Many current traffic density models are based on the continuous flow of

traffic on a freeway. But multiple lights interrupt traffic on arterial roads, and drivers have multiple turn options at each intersection.

"What we found is that it's not easy to estimate density on a signalized link," Liu said. "The traffic dynamics are actually very complex. First, your measurements are not ideal. Second, the current traffic flow model is really a coarse approximation of the real world." In addition, his team assumed they would only know the trajectories of a portion of the GPS-equipped vehicles, or probe cars.

To adjust for the incomplete data, Liu used a Kalman filtering model, which allowed him to combine the two data sources and filter out potential errors, both in measuring and in estimating the traffic. Liu and his team then merged hardware-in-the-loop data from a signalized arterial road with GPS speeds and detector counts in a computer model and tested examples for a signal link with eight different GPS penetration rates.

By using this Kalman filtering model, combined with the data, the researchers were better able to estimate the traffic density on a signalized link, Liu said. "This density estimate is the critical piece for traffic signal timing."

The researchers found that a 10 percent penetration rate of GPS-equipped vehicles was critical to ensure accurate density estimates, but additional GPS-equipped vehicles did not improve the estimation error rates significantly.

With several states currently pursuing funding for the Federal Highway Administration's IntelliDriveSM research, Liu sees his model as an important step forward. (IntelliDrive is a multimodal initiative seeking to enable networked wireless communications among vehicles, the infrastructure, and passengers' personal communications devices.) Although IntelliDrive tests are still in the early stages, the networking capability of vehicles on the road is "increasingly becoming universal," he said. "If it's going to happen, we're well prepared to take this to the next step."



Henry Liu



Researchers are working on a new method that would feed real-time traffic data into signals on arterial roads.



*The use of cameras for red light enforcement raises privacy and legal issues.*

## Research: Social and Economic Policy Issues Related to ITS Technologies

### The Implications of Current and Emerging Privacy Law for ITS

Imagine a driver in the not-so-distant future rushing to meet a new client. As she drives, the car's GPS helps navigate unfamiliar roads; traffic-monitoring technologies warn of potential traffic delays ahead and suggest alternative routes.

The driver arrives at her destination safely with time to spare. But as she turns off the ignition, an on-screen display informs her that she owes \$315 in traffic fines—for speeding, improper lane changes, and failure to come to a complete stop at a crosswalk. All offenses were recorded and reported to local law enforcement agencies by the very technologies that assisted her in her travels.

This hypothetical situation may never come to pass, but current developments in intelligent transportation systems (ITS) make such monitoring and enforcement a real possibility. “Most ITS applications gather and compile data, and the potential use of [these] data is beginning to raise privacy concerns,” said Frank Douma, assistant program director of the State and Local Policy Program at the University of Minnesota’s Humphrey Institute of Public Affairs.

Douma recently completed an investigation of the legal and policy implications of new ITS technologies. Assisting Douma were graduate students Jordan Deckenbach, who coauthored the project’s final report, and Steve Frooman, who helped in the early stages of the project, which was sponsored by the ITS Institute. Stephen Simon, a professor at the University of Minnesota Law School, served as expert advisor.

The research team members examined applicable federal and state laws, studied law review articles, and reviewed court decisions. They discovered that the United States currently lacks a comprehensive legal framework for privacy, relying instead on a nebulous web of state



*Frank Douma*

and federal constitutional provisions and statutes.

To help ITS developers anticipate the legal implications of new technologies, Douma and his team created a privacy law “toolbox.” Included are three essential considerations about the range of information that ITS technologies may collect and use.

First, developers should determine where the collected information falls on the spectrum of anonymous versus personally identifiable data. Truly anonymous data present no problem, but the collection of personally identifiable data may lead to legal challenges. To avoid these legal challenges, developers must find creative solutions that minimize the need to collect identifiable data.

Second, when a new technology does require the collection of personally identifiable information, consent becomes an important issue. Allowing drivers or other users to choose to share their information (that is, to “opt in”) is preferable to requiring those who do not want to participate to “opt-out.” When consent is voluntary, liability over ITS information practices can be limited or even waived.

Finally, it is important to determine who will collect the data and with whom the information will be shared, Douma said. Regulatory approaches differ depending on whether data are collected by a government entity or a third-party organization. In each case, the legal challenges and liabilities for ITS managers are different.

Douma and his team also created a taxonomy of privacy expectations and legal protections. Each level of the taxonomy includes the type of observation and its purpose, the vehicle and driver information collected, and the expectation of privacy and legal protection.

On the simplest level, using a counter to monitor traffic flow requires no collection of vehicle or driver information and has virtually no privacy or legal consequences. At the other end of the spectrum, using a

camera to target drivers who run red lights involves the collection of precise information about both vehicle and driver, and so has serious legal consequences.

“We hope that developers will use the toolkit and the taxonomy to create rigorous, lasting applications that will survive legal challenges, or, even better, not

raise them at all,” Douma says.

An article about this research has been published in the University of Illinois *Journal of Law, Technology and Policy*. In a follow-up project, Douma will study how to address political concerns raised by ITS technologies and how best to tie these concerns to legal remedies.

## Minnesota UPA Telework Component

You love your job, but the commute is painful. Gas is expensive and traffic is bumper-to-bumper. What if you could work from home and avoid the commute, at least a day or two each week? Not only might you be happier and more productive, but the benefits of your telecommuting would also extend to the environment and area roads.

Telework—the ability to work from home and connect to office, coworkers, and clients via the Internet, phone, and mobile devices—has the potential to limit the need for expanded transportation infrastructure. Less driving also means reductions in vehicle-miles traveled (VMT), auto emissions, and greenhouse gases. An estimated 40 percent—or about 700,000—of the Twin Cities’ 1.8 million residents have the type of job that would allow them to work from home at least part of the time.

In 2007, the United States Department of Transportation selected the Minnesota Department of Transportation and the Twin Cities Metropolitan Council to participate in its Urban Partnership Agreement program (UPA). The purpose of the program is to reduce congestion in urban areas through the use of the “4Ts”: tolling, transit, technology, and telework. The Minnesota UPA projects focus specifically on traffic congestion in the I-35W corridor and downtown Minneapolis.

The original goal of the Minnesota UPA telework component sponsored by Mn/DOT was to recruit and retain 500 new telecommuters in the Twin Cities metro area. After the project was rebranded as eWorkPlace, the

goal was expanded to 2,700 participants to be recruited between June 2009 and June 2010. The project also aimed to reduce congestion in the metro area by shifting a minimum of 5,400 trips each week from peak to non-peak hours.

According to Adeel Lari, a research fellow and director of innovative financing at the University’s Humphrey

*Research assistant Cynthia Yuen, research fellow Adeel Lari, and research assistant Denise Huynh examined the benefits of telecommuting.*





Institute of Public Affairs, these goals have been met. Lari, who directed the project, was assisted by graduate students Denise Huynh and Cynthia Yuen.

EWorkPlace also attracted more than 30 employers, ranging in size from Design 1, with 20 employees, to Hennepin County, with more than 8,000 employees—about 18 percent of whom were able to participate.

The research team used electronic survey techniques to collect information from participating employees and companies. Employees kept a survey diary and were asked questions that assessed qualitative and behavioral changes.

The collected data indicate that the average eWorkPlace participant saves about \$10 per telework day in fuel and vehicle maintenance costs. Since the typical teleworker works remotely 2.4 times per week, or the equivalent of approximately five commute trips, the annual savings add up to about \$1,170.

Employees also reported a reduction of more than 30 percent in peak period trips, as well as a reduction of more than 46 percent in VMT. In addition, eWorkPlace participants saved an estimated 22.5 minutes in commute time on telework days. Over the course of a year, this frees up more than 43 hours to spend with family, volunteer, invest in professional growth opportunities, exercise, or work on a hobby.

Companies were surveyed before they began participating in eWorkPlace, three months after they started, and again after nine months. In general, employers reported increased productivity, better retention, and reduced absenteeism. Fairview Health Services, for example, documented less stress, better well-being, higher expectations, and improved relationships for both managers and employees. The company also noted a 50 percent decrease in overtime hours and a 3.6 percent decrease in the average number of trips made by employees during rush hour.

“Minnesota is the only UPA partner that has mounted such a far-reaching telework program,” Lari



*Data indicate that the average eWorkPlace participant saves about \$10 per telework day in fuel and maintenance costs.*

says. “It includes public education and outreach, as well as comprehensive measurement and evaluation.” The eWorkPlace Web site ([www.eworkplace-mn.com](http://www.eworkplace-mn.com)) offers information about telecommuting, employer resources, a “press room” with the latest news about the project, and a blog written by Lari. EWorkPlace also has its own Facebook page, and fans of telework can follow eWorkPlace on Twitter.

Minneapolis mayor R.T. Rybak, St. Paul mayor Chris Coleman, Bloomington mayor Gene Winstead, and Minnesota governor Tim Pawlenty all proclaimed April 2010 “Explore and Experience Telework Month.” In addition, a bill introduced into the Minnesota House of Representatives during the 2009–2010 session called for allowing state workers in appropriate jobs to “perform telework during at least 20 percent of the [their] normal expected hours of work in each pay period.”

Lari expects eWorkPlace to continue beyond the UPA completion date in December 2010. In a follow-up project, he will focus on measuring the economic benefit of telework to employers and their bottom lines.

## FY10 ITS Institute research projects

Projects are listed under their corresponding research category and alphabetically by principal investigator. Project summaries and additional information for each research project listed in this section are online on the ITS Institute's Web site at [www.its.umn.edu/Research](http://www.its.umn.edu/Research).

### Human Performance and Behavior

**Janet Creaser, Alec Gorjestani, and Michael Manser**, Department of Mechanical Engineering  
Usability Evaluation of the Teen Driver Support System

► **Status:** In progress

**Janet Creaser and Michael Manser**, Department of Mechanical Engineering  
Development and Evaluation of a Second-Generation In-Vehicle Driver Assistance for Teenagers to Facilitate a Reduction in Crash Rates

✓ **Status:** Complete



**Max Donath**, Department of Mechanical Engineering  
Smartphone-Based Novice Teenage Driver Support System

► **Status:** In progress

**Kathleen Harder and John Bloomfield**, College of Design  
Comparison of Dual-Phase and Static Signage

✓ **Status:** Complete

**Kathleen Harder and John Bloomfield**, College of Design  
The Effectiveness and Safety of Traffic- and Non-Traffic-Related Messages Presented on Changeable Message Signs (Phase II)

✓ **Status:** Complete

**Caroline Hayes**, Department of Mechanical Engineering  
In-Vehicle Decision Support to Reduce Crashes at Rural Thru-Stop Intersections

► **Status:** In progress

**Caroline Hayes**, Department of Mechanical Engineering  
Usable and Effective Haptic Interfaces for In-Vehicle Decision Support

★ **Status:** New

**Keith Knapp**, formerly, Humphrey Institute of Public Affairs  
Speed Impacts of Occasional Hazard Residential Street Warning Signs

► **Status:** In progress

**Michael Manser**, Department of Mechanical Engineering, and **Michael Rakauskas**, formerly, Department of Mechanical Engineering  
Requirements for Effective Fuel Economy Displays for Improving Fuel Economy and Safety

► **Status:** In progress

**Michael Manser and Craig Shankwitz**, Department of Mechanical Engineering  
An Evaluation of a Prototype Safe Teen Car

► **Status:** In progress

**Thomas Smith**, Department of Kinesiology, and **Nikolaos Papanikolopoulos**, Department of Computer Science and Engineering  
Warning Efficacy of Active Versus Passive Warnings for Unsignalized Intersection and Mid-Block Pedestrian Cross-Walks

✓ **Status:** Complete

**Jiann-Shiou Yang**, Department of Electrical and Computer Engineering (Duluth)  
An Onboard Virtual Rumble-Strip-Based Operation for Road Departure Warning

★ **Status:** New

**Xun Yu**, Department of Mechanical and Industrial Engineering (Duluth)  
Real-time Non-intrusive Detection of Driver Drowsiness (Phase I)

✓ **Status:** Complete

**Xun Yu**, Department of Mechanical and Industrial Engineering (Duluth)  
Real-time Non-intrusive Detection of Driver Drowsiness (Phase II)

► **Status:** In progress

**Xun Yu**, Department of Mechanical and Industrial Engineering (Duluth)  
Integrated Approach for Non-intrusive Detection of Driver Drowsiness

★ **Status:** New

**Debao Zhou**, Department of Mechanical and Industrial Engineering (Duluth)  
Infrared Thermal Camera-Based Real-Time Identification and Tracking of Large Animals to Prevent Animal-Vehicle Collisions (AVCs) on Roadways

★ **Status:** New

### Computing, Sensing, Communications, and Control Systems

**Hongyi Chen**, Department of Mechanical and Industrial Engineering (Duluth)  
Developing an Intelligent Decision Support System for the Proactive Implementation of Traffic Safety Strategies

★ **Status:** New

**Max Donath, Craig Shankwitz, and Michael Manser**, Department of Mechanical Engineering  
CICAS Stop Sign Assist (SSA) System

► **Status:** In progress



**John Evans**, Department of Chemistry and Biochemistry (Duluth)  
Detection of Water and Ice on Bridge Structures by AC Impedance and Dielectric Relaxation Spectroscopy (Phase I)

✓ **Status:** Complete

**John Evans**, Department of Chemistry and Biochemistry (Duluth)  
Detection of Water and Ice on Bridge Structures by AC Impedance and Dielectric Relaxation Spectroscopy (Phase II)

► **Status:** In progress

**John Evans**, Department of Chemistry and Biochemistry (Duluth)  
Detection of Water and Ice on Bridge Structures by AC Impedance and Dielectric Relaxation Spectroscopy (Phase III)

► **Status:** In progress

**John Evans**, Department of Chemistry and Biochemistry (Duluth)  
Deployment and Field Testing of Novel Water and Ice Sensor Systems on Bridge Decks

★ **Status:** New

**Demoz Gebre-Egziabher**, Department of Aerospace Engineering and Mechanics, and **Craig Shankwitz**, Department of Mechanical Engineering  
Development of an Accurate and Low-Cost GPS-Based Heading Determination System

★ **Status:** New

**Demoz Gebre-Egziabher**, Department of Aerospace Engineering and Mechanics, and **Craig Shankwitz**, Department of Mechanical Engineering  
Using Velocity Constraints to Enhance Carrier Phase GPS Robustness

★ **Status:** New

**Justin Graving and Michael Manser**, Department of Mechanical Engineering  
Development of a Proximity Warning System for Use Within Construction Work Zones to Notify Pedestrian Workers of Hazards

★ **Status:** New

**M. Imran Hayee**, Department of Electrical and Computer Engineering (Duluth)  
Development of a Low-Cost Interface between Cell Phones and DSRC-Based Vehicle Unit for Efficient Use of VII Infrastructure

► **Status:** In progress

**M. Imran Hayee**, Department of Electrical and Computer Engineering (Duluth)  
Development of a Portable Work Zone Traffic Information System Based on DSRC and Bluetooth-Enabled Cell Phones

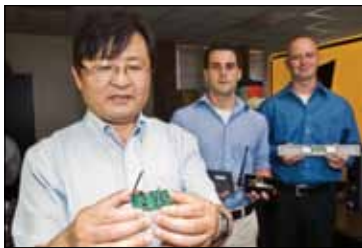
► **Status:** In progress

**M. Imran Hayee**, Department of Electrical and Computer Engineering (Duluth)  
Development of a Portable Traffic Safety Information System for Congested U.S. Roadways Using Vehicle-to-Vehicle (V2V)-Assisted Vehicle-to-Infrastructure (V2I) Communication Using Dedicated Short-Range Communication (DSRC) Technology  
★ **Status:** New

**Eil Kwon**, Department of Civil Engineering (Duluth)  
Assessment of Capacity Estimation Methods for a Multi-lane Roundabout with Field Traffic Data  
▶ **Status:** In progress

**Eil Kwon**, Department of Civil Engineering (Duluth)  
Development of Freeway Management and Operational Strategies with IRIS-In-Loop Simulation  
▶ **Status:** In progress

**Taek Kwon**, Department of Electrical and Computer Engineering (Duluth)  
Cellular Wireless Mesh Sensor Network for Comprehensive Spatial Traffic Movement Detection and Data Fusion (Phase II)  
✓ **Status:** Complete



**Taek Kwon**, Department of Electrical and Computer Engineering (Duluth)  
Development of Data Warehouse and Applications for Continuous Vehicle Class and Weigh-in-Motion (WIM) Data  
✓ **Status:** Complete

**Taek Kwon**, Department of Electrical and Computer Engineering (Duluth)  
Migration of Automatic Traffic Recorder (ATR) and Short-Duration Traffic Data Warehouse at UMD Data Center to Mn/DOT Office of Transportation Data and Analysis (TDA)  
✓ **Status:** Complete

**Taek Kwon**, Department of Electrical and Computer Engineering (Duluth)  
Advanced Dynamic LED Warning Signs for Rural Intersections Powered by Renewable Energy  
▶ **Status:** In progress

**Taek Kwon**, Department of Electrical and Computer Engineering (Duluth)  
Development of a Weigh-Pad-Based Portable Weigh-in-Motion (WIM) System  
▶ **Status:** In progress

**David Levinson**, Department of Civil Engineering (former PI: **Ahmed El-Geneidy**, formerly, Department of Civil Engineering), and **Kevin Krizek**, formerly, Humphrey Institute of Public Affairs  
Using Archived ITS Data to Improve Transit Performance and Management  
✓ **Status:** Complete

**Chen-Fu Liao** and **Gary Davis**, Department of Civil Engineering  
Automate Traffic Data Quality Verification and System Malfunction Identification for Automatic Traffic Recorder (ATR) and Weigh-in-Motion (WIM) Systems  
★ **Status:** New

**Henry Liu** and **Chen-Fu Liao**, Department of Civil Engineering  
Mining Bus Automatic Vehicle Location (AVL) and Automatic Passenger Count (APC) Database for Intelligent Transit Applications  
✓ **Status:** Complete

**Venkatram Mereddy**, Department of Chemistry and Biochemistry (Duluth)  
Development of Hydrogen-Based Power Systems for ITS Applications  
▶ **Status:** In progress

**Vassilios Morellas** and **Nikolaos Papanikolopoulos**, Department of Computer Science and Engineering  
Mass Transit Surveillance and Early Warning System  
✓ **Status:** Complete

**Nikolaos Papanikolopoulos**, Department of Computer Science and Engineering  
Data Mining of Traffic Video Sequences  
✓ **Status:** Complete

**Nikolaos Papanikolopoulos**, Department of Computer Science and Engineering  
Deployment of Practical Methods for Counting Bicycling and Pedestrian Use of a Transportation Facility  
▶ **Status:** In progress

**Nikolaos Papanikolopoulos** and **Vassilios Morellas**, Department of Computer Science and Engineering  
Analysis of Practical Methods for Counting Bicycling and Pedestrian Use of a Transportation Facility  
✓ **Status:** Complete

**Nikolaos Papanikolopoulos** and **Vassilios Morellas**, Department of Computer Science and Engineering  
Counting Empty Parking Spots at Truck Stops  
▶ **Status:** In progress

**Nikolaos Papanikolopoulos** and **Vassilios Morellas**, Department of Computer Science and Engineering  
Monitoring the Use of HOV and HOT Lanes  
★ **Status:** New

**Rajesh Rajamani**, Department of Mechanical Engineering  
Automatic Safety Alert System for Work Zones with Flag Operators  
✓ **Status:** Complete

**Rajesh Rajamani**, Department of Mechanical Engineering  
New Battery-Less Wireless Traffic Sensors as a Replacement for Loop Detectors  
✓ **Status:** Complete

**Rajesh Rajamani**, Department of Mechanical Engineering  
Enhancement and Field Test Evaluation of New Battery-Less Wireless Traffic Sensors  
▶ **Status:** In progress

**Rajesh Rajamani**, Department of Mechanical Engineering  
Ultra-Reliable Detection of Imminent Collision for Enhanced Passenger Safety  
▶ **Status:** In progress

**Rajesh Rajamani** and **Lee Alexander**, Department of Mechanical Engineering  
Automated Vehicle Location, Data Recording, Friction Measurement, and Applicator Control for Winter Road Maintenance  
✓ **Status:** Complete

**Rajesh Rajamani** and **Lee Alexander**, Department of Mechanical Engineering  
Prediction and Prevention of Tripped Rollovers  
★ **Status:** New

**Ryan Rosandich**, Department of Industrial Engineering (Duluth)  
Improve Safety and Efficiency of Roadway Maintenance by Developing a Robotic Roadway Message Painter  
▶ **Status:** In progress

**Craig Shankwitz**, Department of Mechanical Engineering  
Analysis of Highway Design and Geometric Effects on Crashes  
✓ **Status:** Complete

**Craig Shankwitz**, Department of Mechanical Engineering  
Guidance Augmentation Using VPS for Transit Applications, Year 2  
✓ **Status:** Complete

**Craig Shankwitz**, Department of Mechanical Engineering  
Technology for Transit: Lane Guidance for Shoulder-Running Buses  
✓ **Status:** Complete

**Craig Shankwitz**, Department of Mechanical Engineering  
In-Situ Testing of State Patrol Vehicle Lighting, Retro-reflectors, and Paint  
▶ **Status:** In progress

**Craig Shankwitz**, Department of Mechanical Engineering  
Inexpensive 2-D Optical Sensor for DGPS Augmentation  
▶ **Status:** In progress

**Craig Shankwitz**, Department of Mechanical Engineering  
Rural Intersection Collision Avoidance System (RICAS) Design, Integration and Project Management Services  
▶ **Status:** In progress

**Craig Shankwitz** and **Max Donath**, Department of Mechanical Engineering  
GPS Augmentation for Robust Lane Assistance on Cedar Avenue in Support of the Urban Partnership Agreement  
▶ **Status:** In progress

**Shashi Shekhar**, Department of Computer Science and Engineering, and **Henry Liu**, Department of Civil Engineering  
Information Integration and Informatics—Contextual Research (III-CXT): Spatio-Temporal Graph Databases for Transportation Science  
▶ **Status:** In progress

**Hua Tang**, Department of Electrical and Computer Engineering (Duluth)  
Development of a New Tracking System Based on CMOS Vision Processor Hardware (Phase I)  
✓ **Status:** Complete



**Hua Tang**, Department of Electrical and Computer Engineering (Duluth)  
Development of a New Tracking System Based on CMOS Vision Processor Hardware (Phase II)  
► **Status:** In progress

**Hua Tang**, Department of Electrical and Computer Engineering (Duluth)  
A Tracking-Based Traffic Performance Measurement System for Roundabouts and Intersections  
★ **Status:** New

**Peter Willemsen**, Department of Computer Science (Duluth)  
Snow Rendering for Interactive Snowplow Simulation—Improving Driver Ability to Avoid Collisions When Following a Snowplow  
► **Status:** In progress

**Peter Willemsen**, Department of Computer Science (Duluth), **Lee Zimmerman**, Department of Electrical and Computer Engineering (Duluth), and **Albert Yonas**, Department of Child Development  
Snow Rendering for Interactive Snowplow Simulation—Supporting Safety in Snowplow Design (Phase I)  
► **Status:** In progress

**Peter Willemsen**, Department of Computer Science (Duluth), **Lee Zimmerman**, Department of Electrical and Computer Engineering (Duluth), and **Albert Yonas**, Department of Child Development (Duluth)  
Snow Rendering for Interactive Snowplow Simulation—Supporting Safety in Snowplow Design (Phase II)  
► **Status:** In progress

### Technologies for Modeling, Managing, and Operating Transportation Systems

**Gary Davis and John Hourdos**, Department of Civil Engineering  
Access to Destinations: Arterial Data Acquisition and Network-Wide Travel Time Estimation (Phase II)  
✓ **Status:** Complete

**Gary Davis and John Hourdos**, Department of Civil Engineering  
Access to Destinations: Streamlining the Arterial Data Acquisition and the Estimation of Network-Wide Travel Link Times  
► **Status:** In progress

**Gary Davis, John Hourdos, and Chen-Fu Liao**, Department of Civil Engineering  
Estimating the Crash Reduction and Vehicle Dynamic Effects of Flashing LED Stop Signs  
★ **Status:** New

**Gary Davis and Henry Liu**, Department of Civil Engineering  
Using Detailed Signal and Detector Data to Investigate Intersection Crash Causation  
► **Status:** In progress



**Max Donath**, Department of Mechanical Engineering  
Aggregating VMT within Predefined Geographic Zones Using a Cellular Network  
► **Status:** In progress

**Max Donath**, Department of Mechanical Engineering  
Analysis of the Impact of Road Use for Alternate Transportation in Denali Park  
► **Status:** In progress

**Robert Feyen**, Department of Mechanical and Industrial Engineering (Duluth)  
Assessing Coordination between Agencies Involved in Traffic Incident Management  
✓ **Status:** Complete

**Demo Gebre-Egziabher and Greg Nelson**, Department of Aerospace Engineering and Mechanics  
Analysis of Uninhabited Aerial Vehicles ITS Concept of Operations  
► **Status:** In progress

**Nikolas Geroliminis**, formerly, Department of Civil Engineering  
Investigation of Flash LADAR 3D Imaging Sensor Technology for Non-Intrusive Roadside Traffic Measures  
✓ **Status:** Complete

**John Hourdos**, Department of Civil Engineering  
Portable, Non-Intrusive Advance Warning Devices for Work Zones with or without Flag Operators  
► **Status:** In progress

**John Hourdos**, Department of Civil Engineering, and **Seraphin Chally Abou**, Department of Mechanical and Industrial Engineering (Duluth)  
Effectiveness of Urban Partnership Agreement (UPA) Measures in the I-35W Corridor  
★ **Status:** New

**John Hourdos and Gary Davis**, Department of Civil Engineering  
TH-36 Full Closure Construction: Evaluation of Traffic Operations Alternatives  
✓ **Status:** Complete

**John Hourdos and Gary Davis**, Department of Civil Engineering, and **Nikolas Geroliminis**, formerly, Department of Civil Engineering  
Vehicle Probe-Based Real-Time Traffic Monitoring on Arterials  
► **Status:** In progress

**John Hourdos and Panos Michalopoulos**, Department of Civil Engineering  
Development of Next Generation Simulation Models for Twin Cities: Freeway Metro-Wide Simulation Model (Phase I)  
► **Status:** In progress

**David Levinson and Henry Liu**, Department of Civil Engineering, and **Kathleen Harder**, College of Design  
Traffic Flow and Road User Impacts of the Collapse of the I-35W Bridge Over the Mississippi River  
► **Status:** In progress



**Chen-Fu Liao**, Department of Civil Engineering  
Using Archived Truck GPS Data for Freight Performance Analysis on Interstate I-94/I-90 from the Twin Cities to Chicago  
✓ **Status:** Complete

**Chen-Fu Liao and Gary Davis**, Department of Civil Engineering  
Bus Signal Priority Based on GPS and Wireless Communications (Phase III)—Bus to Roadside Infrastructure Communication Framework for Intelligent Transportation  
► **Status:** In progress

**Chen-Fu Liao and Henry Liu**, Department of Civil Engineering  
Advanced System Analysis for Public Transit (ASAPT) Using Data-Driven Transit Performance Measures for Transit Network Analysis  
► **Status:** In progress

**Chen-Fu Liao**, Department of Civil Engineering, and **Michael Rakauskas**, formerly, Department of Mechanical Engineering  
Accessible Traffic Signals for Blind and Visually Impaired Pedestrians  
► **Status:** In progress

**Henry Liu**, Department of Civil Engineering  
Development of a Platoon-Priority Control Strategy and Smart Advance Warning Flashers for Isolated Intersections with High-Speed Approaches  
✓ **Status:** Complete

**Henry Liu**, Department of Civil Engineering  
Evaluation of Cell Phone Traffic Data  
✓ **Status:** Complete

**Henry Liu**, Department of Civil Engineering  
Real-Time Arterial Performance Monitoring System  
✓ **Status:** Complete

**Henry Liu**, Department of Civil Engineering  
Responding to the Unexpected: Development of a Dynamic Data-Driven Traffic Operation Model for Effective Evacuation  
✓ **Status:** Complete

**Henry Liu**, Department of Civil Engineering  
Estimating and Measuring Arterial Travel Time and Delay  
► **Status:** In progress

**Henry Liu**, Department of Civil Engineering  
Further Development of the SMART-Signal System with the City of Eden Prairie  
► **Status:** In progress

**Henry Liu and David Levinson**, Department of Civil Engineering, and **Kathleen Harder**, College of Design  
BRIDGE: Behavioral Response to the I-35W Disruption: Gauging Equilibration  
► **Status:** In progress

**Henry Liu and Chen-Fu Liao**, Department of Civil Engineering  
SMART-Signal: Systematic Monitoring of Arterial Road Traffic and Signals (Phase II)  
► **Status:** In progress

**Henry Liu and Panos Michalopoulos**, Department of Civil Engineering  
Development of Algorithms for Travel-Time-Based Traffic Signal Timing (Phase I)  
► **Status:** In progress

**Henry Liu and Panos Michalopoulos**, Department of Civil Engineering  
Development of the Next Generation Metro-Wide Simulation Models for the Twin Cities' Metropolitan Area: Mesoscopic Modeling  
► **Status:** In progress

**Panos Michalopoulos**, Department of Civil Engineering  
Transportable Low-Cost Traffic Data Collection Device for Rapid Deployment for Intersections and Arterials  
✓ **Status:** Complete

**Panos Michalopoulos**, Department of Civil Engineering  
Low-Cost Portable Video-Based Queue Detection for Work Zone Safety  
► **Status:** In progress



**Panos Michalopoulos**, Department of Civil Engineering, and **Nikolas Geroliminis**, formerly, Department of Civil Engineering  
Development of the Next-Generation Stratified Ramp Metering Algorithm Based on Freeway Density  
► **Status:** In progress

**Xun Yu**, Department of Mechanical and Industrial Engineering (Duluth)  
Intelligent Pavement for Traffic Flow Detection (Phase I)  
► **Status:** In progress

**Xun Yu**, Department of Mechanical and Industrial Engineering (Duluth)  
Intelligent Pavement for Traffic Flow Detection (Phase II)  
► **Status:** In progress

## Social and Economic Policy Issues Related to ITS

**John Bryson, Barbara Crosby, and Melissa Stone**, Humphrey Institute of Public Affairs  
Technology and Collaboration in Effective Transportation Policy  
✓ **Status:** Complete

**John Bryson, Barbara Crosby, and Melissa Stone**, Humphrey Institute of Public Affairs  
From Start to Finish: Cross-Sector Collaboration and the Urban Partnership Agreement  
► **Status:** In progress

**John Bryson, Barbara Crosby, and Melissa Stone**, Humphrey Institute of Public Affairs  
Urban Partnership Agreement: A Comparative Study of Technology and Collaboration in Transportation Policy Implementation  
► **Status:** In progress

**Jason Cao and Frank Douma**, Humphrey Institute of Public Affairs  
Substitution between E-shopping and Travel: Evidence from the Twin Cities  
► **Status:** In progress

**Jason Cao and Lee Munnich**, Humphrey Institute of Public Affairs  
Benefit-Cost Analysis of Value Pricing: Case Study for MnPass  
► **Status:** In progress

**Frank Douma**, Humphrey Institute of Public Affairs  
ITS and Privacy: Developing New Rules for Virtual Roads  
✓ **Status:** Complete

**Frank Douma**, Humphrey Institute of Public Affairs  
ITS and Locational Privacy: Suggestions for Peaceful Coexistence  
► **Status:** In progress

**Thomas Horan**, Humphrey Institute of Public Affairs  
ITS and Safety Planning: ITS and EMS System Data Integration for Safety and Crisis Information and Decision-Making Systems  
✓ **Status:** Complete

**Thomas Horan and Benjamin Schooley**, Humphrey Institute of Public Affairs  
ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment (Phase II)  
► **Status:** In progress

**Thomas Horan and Benjamin Schooley**, Humphrey Institute of Public Affairs  
ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment (Phase III)  
► **Status:** In progress

**David Levinson**, Department of Civil Engineering  
The Role of Social Networks and Information and Communications Technology (ICT) on Destination Choice  
✓ **Status:** Complete

**Greg Lindsey**, Humphrey Institute of Public Affairs  
Understanding the Use of Nonmotorized Transportation Facilities through Application of Infrared and Radio-Frequency Technologies  
► **Status:** In progress

**Lee Munnich, Ferrol Robinson, and Zhao Zhirong**, Humphrey Institute of Public Affairs  
Implementing Distance-Based User Fees as a Replacement for the Fuel Tax  
► **Status:** In progress

**Carissa Schively Slotterback**, Humphrey Institute of Public Affairs, and **John Hourdos**, Department of Civil Engineering  
Technology in Planning and Participatory Processes: Identifying New Synergies through Real World Application  
► **Status:** In progress

**Elizabeth Wilson**, Humphrey Institute of Public Affairs, **Kevin Krizek**, University of Colorado (formerly, Humphrey Institute of Public Affairs), and **Julian Marshall**, Department of Civil Engineering  
School Travel and the Implications for Advances in Transportation-Related Technology  
► **Status:** In progress

**Elizabeth Wilson**, Humphrey Institute of Public Affairs, and **Julian Marshall**, Department of Civil Engineering  
Decision Tools for Assessing Transportation Impacts of School Policy and School Choice  
► **Status:** In progress

## Selected publication of work by ITS Institute researchers in FY10

Atev, S., Miller, G., and Papanikolopoulos, N. (2010). Clustering of vehicle trajectories. *IEEE Transactions on ITS*.

Ban, J., Ferris, M., and Liu, H. (2010). Numerical studies on reformulation techniques for continuous network design with asymmetric user equilibria. *International Journal of Operations Research and Information Systems*, 1(1): 5272.

Becic, E., Dell, S.G., Bock, K., Garnsey, M.S., Kubose, T., and Kramer, A.F. (2010). Driving impairs talking. *Psychometric Bulletin and Review*, 17: 15–21.

Bodor, R., Jackson, B., Masoud, O., Fehr, D., and Papanikolopoulos, N.P. (2009). View-independent motion classification using image-based reconstruction. *Image and Vision Computing*, 27(8): 1194–1206.

Boot, W.R., Becic, E., and Kramer, A.F. (2009). Stable individual differences in search strategy? The effects of task demands and motivational factors on scanning strategy in visual search. *Journal of Vision*, 9: 1–16.

Brashaw, B., Vatalaro, R., Wang, X., Verreux, M., Sarvela, K., and Wacker, J. (2009). Development of flexural vibration inspection to rapidly assess the structural health of rural bridge systems: Phase II. *Proceedings of the 16th International Symposium on Nondestructive Testing and Evaluation of Wood*.

Cao, X. (2009). E-shopping, spatial attributes, and personal travel: a review of empirical studies. *Journal of the Transportation Research Board*, 2135: 160–169.



Xinyu (Jason) Cao

Cao, X., Masoud, O., Boley, D., and Papanikolopoulos, N.P. (2009). Online motion classification using support vector machines. *Computer Vision and Image Understanding*, 113(10): 1064–1075.

Creaser, J., Lenneman, J., and Szczerba, J. (2009). Design and evaluation of serial-hybrid vehicle energy gauges. *Proceedings of the 5th International Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design*.

Creaser, J., Rakauskas, M., Manser, M., and Ward, N. (2009). Evaluating design options for a dynamic traffic sign. *Proceedings of the 5th International Symposium on Human Factors in Driver Assessment, Training and Vehicle Design*.



Barbara Crosby

Crosby, B.C., Bryson, J.B., and Stone, M.M. (2010). Leading across frontiers: how visionary leaders integrate people, processes, structures and resources. In Osbourne, S. (ed.), *The New Public Governance*. London: Routledge.

Davis, G.A. (2009). Sample-based Bayesian reconstruction of road accidents. *Journal of Transportation Safety and Security*, 1: 181–189.

Davis, G.A., and Morris, P. (2009). Statistical versus simulation models in safety: steps toward a synthesis using

Cao, X., Douma, F., and Cleaveland, F. (in press). The influence of e-shopping on shopping travel: evidence for the Twin Cities. *Transportation Research Record*.

Cao, X., Masoud, O., Boley, D., and Papanikolopoulos, N.P. (2009). Online motion classification using support vector machines. *Computer Vision and Image Understanding*, 113(10): 1064–1075.

Creaser, J., Lenneman, J., and Szczerba, J. (2009). Design and evaluation of serial-hybrid vehicle energy gauges. *Proceedings of the 5th International Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design*.

Creaser, J., Rakauskas, M., Manser, M., and Ward, N. (2009). Evaluating design options for a dynamic traffic sign. *Proceedings of the 5th International Symposium on Human Factors in Driver Assessment, Training and Vehicle Design*.

Crosby, B.C., Bryson, J.B., and Stone, M.M. (2010). Leading across frontiers: how visionary leaders integrate people, processes, structures and resources. In Osbourne, S. (ed.), *The New Public Governance*. London: Routledge.

Davis, G.A. (2009). Sample-based Bayesian reconstruction of road accidents. *Journal of Transportation Safety and Security*, 1: 181–189.

Davis, G.A., and Morris, P. (2009). Statistical versus simulation models in safety: steps toward a synthesis using

median crossing crashes. *Transportation Research Record*, 2102: 93–100.

Davis, G.A., Xiong, H., and Tao, H. (2009). Application of Bayesian statistics to identify highway sections with atypically high rates of median crossing collisions. *Transportation Research Record*, 2136: 77–81.



Caroline Hayes

Drew, D., and Hayes, C. (2010). In-vehicle decision support to reduce crashes at rural thru-stop intersections. *Proceedings of the Human Factors and Ergonomics Society 53rd Annual Meeting*.

Erdogan, G., Alexander, L., and Rajamani, R. (2010). Closed-loop snowplow application control using road condition measurements. *Vehicle System Dynamics*.

Erdogan, G., Alexander, L., and Rajamani, R. (2010). A novel wireless piezoelectric tire sensor for the estimation of slip angle. *Measurement Science and Technology*, 21(1).

Erdogan, G., Alexander, L., and Rajamani, R. (2009). Active vibration cancellation for tire road friction estimation. *Proceedings of the ASME Dynamic Systems and Control Conference*.

Erdogan, G., Alexander, L., and Rajamani, R. (2009). Novel wireless tire deformation sensors for estimation of slip angle. *Proceedings ASME Dynamic Systems and Control Conference*.

Fischer, J., Menon, A., Gorjestani, A., Shankwitz, C., and Donath, M. (2009). Range sensor evaluation for use in cooperative intersection collision avoidance systems. *Proceedings of the 2009 IEEE Vehicular Networking Conference*, 28: 221–228.

Geroliminis, N., Karlaftis, M.G., and Skabardonis, A. (2009). A spatial queuing model for the emergency vehicle districting and location problem. *Transportation Research Part B*, 43(7): 798–811.

Geroliminis, N., and Levinson, D. (2009). Cordon pricing consistent with the physics of overcrowding. *Transportation and Traffic Theory 2009: Golden Jubilee*: 219–240.

Han, B., Yu, X., and Kwon, E. (2009). Self-sensing CNT/cement composite for traffic monitoring. *Nanotechnology*, 20: 445–501.

He, J., Becic, E., Lee, Y., and McCarley, J. (2009). Identifying mind-wandering behind the wheel. *Human Factors and Ergonomics Society Annual Meeting Proceedings*, 53: 1146–1150.

He, X., Guo, X., and Liu, H. (2010). A link-based day-to-day traffic assignment model. *Transportation Research Part B*, 44(4): 597–608.

He, B.S., He, X., and Liu, H. (2010). Solving a class of constrained “black-box” inverse variational inequalities. *European Journal of Operations Research*, 204(3): 391–401.

Hu, S., Bowlds, R., Gu, Y., and Yu, X. (2009). Pulse wave sensor for non-intrusive driver's drowsiness detection. *IEEE 31st Annual International Conference of the Engineering in Medicine and Biology Society*, 2312–2315.

Joshi, A., Porikli, F., and Papanikolopoulos, N. (2010). Breaking the interactive bottleneck in multi-class classification with active selection and binary feedback. *The 23rd IEEE Conference on Computer Vision and Pattern Recognition*.

Li, S., Li, R., Rajamani, R., and Wang, J. (in press). Model predictive control theory based multi-objective vehicular adaptive cruise control. *IEEE Transactions on Control Systems Technology*.

Li, P. and Tang, H. (2010). Hardware architecture design for reconfigurable block size motion estimation. *Proceedings of the IEEE International Conference on Consumer Electronics*.

Liao, C., Liu, H., and Levinson, D. (2009). Engaging undergraduate students in transportation studies through simulating transportation for realistic engineering education and training (STREET). *Transportation Research Record*, 2109: 12–21.

Manser, M., Rakauskas, M., Creaser, J., Donath, M., Shankwitz, C., and Starr, R. (2009). Improving driver behavior at rural intersections: issues to be considered when designing stop sign assist and gap decision support systems. *Proceedings of the 2009 National Rural ITS Conference*.

Marich, M., Schooley, B., and Horan, T. (2010). A normative enterprise architecture for guiding end-to-end emergency response decision support. *Annals of Information Systems on Decision Support and Knowledge Management*.

Olsen, M., Deokar, S., Willemssen, P., Erickson, S., and Yonas, A. (2010). Improving driver ability when following a snowplow in winter. *Proceedings of PIVE 2010 (2nd IEEE VR 2010 Workshop on Perceptual Illusions in Virtual Environments)*.



Pavithra Parthasarathi

Parthasarathi, P., and Levinson, D. (in press). Post-construction evaluation of traffic forecast accuracy. *Transport Policy*.

Phanomchoeng, G., and Rajamani, R. (2010). The bounded Jacobian approach to nonlinear observer



design. *Proceedings of the 2010 American Control Conference*.

Phanomchoeng, G., and Rajamani, R. (2010). Observer design for Lipschitz nonlinear systems using Riccati equations. *Proceedings of the 2010 American Control Conference*.

Piyabongkarn, D., Rajamani, R., and Lew, J.Y. (2010). Active driveline torque management systems—individual wheel torque control for active automotive safety applications. *IEEE Control Systems Magazine*, 30(3).

Rajamani, R., Piyabongkarn, D., Lew, J.Y., Yi, K., and Phanomchoeng, G. (2010). Tire road friction coefficient estimation—real-time estimation methods for active automotive safety applications. *IEEE Control Systems Magazine*, 30(3).

Rajamani, R., Piyabongkarn, D., Tsourapas, V., and Lew, J.Y. (2009). Real-time estimation of roll angle CG height for active rollover prevention applications. *Proceedings of the 2010 American Control Conference*.

Sivaramakrishnan, S., Phanomchoeng, R., Rajamani, R., and Gopinath, A. (2009). Development of a wireless angle sensor based on the directional radiation pattern of antennas. *Measurement Science and Technology*, 20(6).

Slotterback, C.S. (2009). Minnesota planners' use of technology. *Planning and Technology Today*, 94: 4–5.

Smith, T.J., Hammond, C., Somasundaram, G., and Papanikolopoulos, N. (2009). Efficacy of active versus passive warnings at uncontrolled pedestrian crosswalks. *Proceedings of the International Ergonomics Association 17th World Congress on Ergonomics*.



Vassilios Morellas

Somasundaram, G., Morellas, V., Papanikolopoulos, N., and Austin, L. (2009). Counting pedestrians and bicycles in traffic scenes. *Conference Proceedings of the 2009 IEEE Conference on ITS*.

Tilahun, N.J., and Levinson, D. (in press). A moment of time: reliability in route choice using stated preference. *Journal of Intelligent Transportation Systems*.

Tsourapas, V., Piyabongkarn, D., Williams, A.C., and Rajamani, R. (2009). New method of identifying real-time predictive lateral load transfer ratio for rollover prevention systems. *Proceedings of the 2009 American Control Conference*.

Veeraraghavan, H., and Papanikolopoulos, N. (2009). Learning to recognize video-based spatio-temporal events. *IEEE Transactions on ITS*, 10(4): 628–638.

Vijayaraghayan, K., and Rajamani, R. (2010). Ultra low power control system for maximal energy harvesting from short duration vibrations. *IEEE Transactions on Control Systems Technology*, 18(2): 252–266.

Wang, X., Khattak, A., and Fan, Y. (2009). Role of dynamic information in supporting changes in travel behavior. *Transportation Research Record: Journal of the Transportation Research Board*, 2138: 85–93.

Wu, X., Levinson, D., and Liu, H. (2009). Perception of waiting time at signalized intersections. *Transportation Research Record: Journal of the Transportation Research Board*, 2135: 52–59.

Xin, W., and Levinson, D. (in press). Stochastic congestion and pricing model

with endogenous departure time selection and heterogeneous travelers. *Mathematical Population Studies*.

Xiong, H., and Davis, G.A. (2009). Field evaluation of model-based estimation of arterial link travel times. *Transportation Research Record: Journal of the Transportation Research Board*, 2130: 149–157.

Zhang, L., Xie, F., and Levinson, D. (2009). Illusion of motion: variation in travel time under different freeway driving conditions. *Transportation Research Record: Journal of the Transportation Research Board*, 2135: 34–42.

## ITS Institute research reports published in FY10

Reports are available in PDF format at [www.its.umn.edu/Publications/ResearchReports](http://www.its.umn.edu/Publications/ResearchReports).

### *Access to Destinations: Application of Accessibility Measures for Non-Auto Travel Modes*

Kevin J. Krizek, Michael Iacono, Ahmed El-Geneidy, Chen-Fu Liao, and Robert Johns  
Mn/DOT 2009-24

### *Access to Destinations: Arterial Data Acquisition and Network-Wide Travel Time Estimation (Phase II)*

Gary A. Davis, John Hourdos, Hui Xiong, and Ted Morris  
Mn/DOT 2010-12

### *Automated Enforcement of Red-Light Running & Speeding Laws in Minnesota: Bridging Technology and Public Policy*

John S. Adams and Barbara J. VanDraeseke  
CTS 09-26



Lee Alexander

### *Automated Vehicle Location, Data Recording, Friction Measurement and Applicator Control for Winter Road Maintenance*

Gurkan Erdogan, Lee Alexander, and Rajesh Rajamani

Mn/DOT 2010-07

### *Benefit: Cost Analysis of In-Vehicle Technologies and Infrastructure Modifications as a Means to Prevent Crashes Along Curves and Shoulders*

Jaswandi Tushar Pitale and Craig Shankwitz  
Mn/DOT 2009-39

### *Comparison of Dual-Phase and Static Changeable Message Signs to Convey Airline Information on Interstate Freeways*

Kathleen A. Harder and John Bloomfield  
Mn/DOT 2010-02



Nikolaos Papanikolopoulos

### *Data Mining of Traffic Video Sequences*

Ajay J. Joshi and Nikolaos P. Papanikolopoulos  
CTS 09-25

### *Development and Evaluation of a Cellular Phone Based Teen Driver Support System*

Janet Creaser, Richard Hoglund, Michael Manser, and Max Donath  
CTS 09-22

### *Development of Data Warehouse and Applications for Continuous Vehicle Class and Weigh-in-Motion Data*

Taek Mu Kwon  
Mn/DOT 2009-33

### *Development of a Platoon-Priority Control Strategy with/out Smart Advance Warning Flashers for Isolated Intersections with High-Speed Approaches*

Henry Liu and Sundeep Bhimireddy  
Mn/DOT 2009-23

### *Evaluation of the SafeLane™ Overlay System for Crash Reduction on Bridge Deck Surfaces*

John F. Evans  
Mn/DOT 2010-13

### *The Implications of Current and Emerging Privacy Law for ITS*

Frank Douma and Jordan Deckenbach  
CTS 08-26

### *Models for Predicting RWIS Sensor Misalignments and Their Causes*

Prafulla Bhalekar, Carolyn J. Crouch, Donald B. Crouch, and Richard M. MacIin  
CTS 10-01

### *Practical Methods for Analyzing Pedestrian and Bicycle Use of a Transportation Facility*

Guruprasad Somasundaram, Vassilios Morellas, and Nikolaos P. Papanikolopoulos  
Mn/DOT 2010-06



Jory Schwach

### *Rapidly Deployable Low-Cost Traffic Data and Video Collection Device*

Jory A. Schwach, Ted Morris, and Panos G. Michalopoulos  
CTS 09-21

### *Responding to the Unexpected: Development of a Dynamic Data-Driven Model for Effective Evacuation*

Henry X. Liu and Saif Eddin Jabari  
Mn/DOT 2009-44

### *TH-36 Full Closure Construction: Evaluation of Traffic Operations Alternatives*

John Hourdos, Feili Hong  
Mn/DOT 2010-04

### *Using Archived Truck GPS Data for Freight Performance Analysis on I-94/I-90 from the Twin Cities to Chicago*

Chen-Fu Liao  
CTS 09-27

## Selected presentations given by ITS Institute researchers in FY10

Agnew, S., Borah, J., Hankey, S., Hoff, K., Utecht, B., Xu, Z., and Lindsey, G. (2010, April). Temporal and spatial variation in non-motorized traffic in Minneapolis: some preliminary analyses. 21st Annual CTS Transportation Research Conference, St. Paul, Minnesota.



Ensar Becic

Becic, E. (2009, November). Should I drive or should I talk? ITS Institute Advanced Transportation Technologies Seminar Series, University of Minnesota, Minneapolis.

Brashaw, B. (2009, October). Development of flexural vibration inspection techniques to rapidly assess the structural health of rural bridge systems. 16th International Symposium on Nondestructive Testing and Evaluation of Wood, Beijing, China.

Brashaw, B., and Vatalaro, R. (2009, September). Flexural vibration inspection techniques. Meadowlands, Minnesota.



Brian Brashaw

Brashaw, B., Vatalaro, R., Wang, X., Ross, R., Sarvela, K., and Wacker, J. (2010, April). Development of flexural vibration inspection techniques to rapidly assess the structural health of timber bridge systems.

21st Annual CTS Transportation Research Conference, St. Paul, Minnesota.

Brashaw, B., Vatalaro, R., Wang, X., Ross, R., Sarvela, K., and Wacker, J. (2009, October). Development of flexural vibration inspection techniques to rapidly assess the structural health of timber bridge systems: phase II. 16th International Symposium on Nondestructive Testing and Evaluation of Wood, Beijing, China.



John Bryson

Bryson, J.M. (2010, February). Practices of integrative leadership. Distinguished Speaker Series, University of Edinburgh Business School, Edinburgh, United Kingdom.

Cao, X. (2010, August). The interactions between e-shopping and traditional in-store shopping: an application of structure equations model. The Seventh International Conference on Traffic & Transportation Studies, Kunming, China.

Cao, X., Douma, F., and Cleaveland, F. (2010, January). The influence of e-shopping on shopping travel: evidence from the Twin Cities. 89th Annual Meeting of the Transportation Research Board, Washington, D.C.

Cao, X., Douma, F., and Cleaveland, F. (2009, October). The influence of e-shopping on shopping travel: evidence from the Twin Cities. Fourth Specialist Meeting of the Network: ICT: Mobilizing Persons, Places, and Spaces, Quebec, Canada.

Creaser, J. (2009, September). Effects of alcohol on motorcycle riding skills. ITS Institute Advanced Transportation Technologies Seminar Series, University of Minnesota, Minneapolis.

Donath, M. (2009, December). Enabling near-term nationwide implementation of distance-based road user fees. International Bridge, Tunnel, and Turnpike Association, Transportation Policy and Finance Summit, Washington, D.C.

Donath, M. (2009, October). Addressing patterns of risk: driver-assist technologies for reducing road fatalities. Center for Transportation and Logistics Distinguished Lecture Series, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Donath, M. (2009, October). Driver-assist technology: deploying bus rapid transit along a narrow lane or road shoulder. Civil Engineering Department's Public Transportation Program Colloquium, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Donath, M. (2009, October). Safe intersections through technology. Minnesota Toward Zero Deaths Conference, Duluth, Minnesota.

Donath, M. (2009, September). Driver-assist technology: deploying bus rapid transit along a narrow lane or road shoulder. KTH Royal Institute of Technology, Stockholm, Sweden.

Donath, M. (2009, September). Driver-assist systems for preventing lane departure. Volvo Technology, Gothenburg, Sweden.

Donath, M. (2009, September). Stop sign-assist at rural intersections. ITS World Congress, Stockholm, Sweden.

Donath, M. (2009, August). Technologies for improving safety at rural unsignalized intersections. Center for Excellence in Rural Safety Annual Summer Institute, Williamsburg, Virginia.

Donath, M. (2009, August). Designing human-centered systems: DGPS-based augmented reality—'seeing' the road. California Department of Transportation Division of Research and Innovation, Sacramento, California.

Donath, M. (2009, August). Designing human-centered systems: DGPS-based augmented reality—'seeing' the road. Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center, University of California, Davis, California.

Donath, M. (2009, July). A new concept for mileage-based road use charging. Transportation Research Board Summer Annual Meeting, Seattle, Washington.

Douma, F. (2010, March). The implications of current and emerging privacy law for ITS. ITS Minnesota 16th Annual Meeting & Information Exchange, St. Paul, Minnesota.

Douma, F. (2009, December). The implications of current and emerging privacy law for ITS. ITS Institute Board meeting, Minneapolis.

Douma, F. (2009, September). ITS and privacy: suggestions for peaceful coexistence. ITS Institute Advanced Transportation Technologies Seminar Series, University of Minnesota, Minneapolis.

Douma, F., Manser, M., and Baas, G. (2009, August). In-vehicle technology: monitoring teen compliance with graduated driver licensing requirements (privacy implications). American Association of Motor Vehicle Administrators 76th Annual International Conference, San Diego, California.

Evans, J.F., Anderson, E., and Busta, L. (2009, December). Detection of road and bridge surface conditions using time domain reflectometry (TDR) and dielectric relaxation spectroscopy (DRS). Department of Chemistry and Biochemistry, University of Minnesota Duluth, Duluth, Minnesota.



Robert Feyen

Feyen, R. (2010, February). Identifying methods and metrics for evaluating interagency coordination in traffic incident management. CTS Research Seminar Series, University of Minnesota, Minneapolis.

Geroliminis, N. (2010, January). Queue spillovers in city street networks with

signal-controlled intersections. 89th Annual Meeting of the Transportation Research Board, Washington, D.C.

Geroliminis, N., Kepaptsoglou, K., and Karlaftis, M. (2010, January). A hybrid hypercube: genetic algorithm approach for deploying many transit mobile repair units in an urban network. 89th Annual Meeting of the Transportation Research Board, Washington, D.C.

Geroliminis, N., and Sun, J. (2010, January). Properties of a well-defined macroscopic fundamental diagram for urban traffic. 89th Annual Meeting of the Transportation Research Board, Washington, D.C.

Gorjestani, A. (2009, October). Range sensor evaluation for use in cooperative intersection collision avoidance systems. 2009 IEEE Vehicular Networking Conference, Tokyo University of Science, Tokyo, Japan.

Hong, F., and Hourdos, J. (2009, June). Evaluating user costs on an arterial-turned-freeway full roadway closure construction project. Second International Symposium on Freeway and Tollway Operations, Honolulu, Hawaii.

Jackels, J. for Manser, M. (2009, August). Improving driver behavior at rural intersections: issues to be considered when designing stop sign assist and gap decision support systems. National Rural ITS Conference, Seaside, Oregon.

Kwon, E., Song, S., Seo, D., and Jung, I. (2010, June). On-line traffic condition and information analysis system for wireless V21 communication. IEEE International Conference on Ubiquitous Future Networks, Jeju Island, South Korea.

Kwon, T. (2009, August). Wireless mesh sensor network for vehicle turning movement counting in an intersection. National Rural ITS Conference, Seaside, Oregon.





Greg Lindsey

Lindsey, G. (2009, November). Modeling traffic on multiuse trails: recent findings and research needs. Mn/DOT Non-Motorized Transportation Research Committee, Shoreview, Minnesota.

Liu, H. (2010, June). Arterial performance measurement using high-resolution traffic signal data. National Science Foundation Workshop on Dynamic Route Guidance and Coordinated Traffic Control, Rutgers University, New Brunswick, New Jersey.

Liu, H. (2010, April). Understanding the day-to-day traffic equilibration process after network disruption: empirical observations and theoretical models. Arizona State University, Tempe, Arizona.

Liu, H. (2010, March). The future of traffic monitoring. North Central Institute of Transportation Engineers (NCITE) Section Meeting and Interdisciplinary Transportation Student Organization (ITSO) Annual Meeting, University of Minnesota, Minneapolis.

Liu, H. (2009). SMART-Signal: systematic monitoring of arterial road traffic signals. Institute of Transportation Studies, University of California, Irvine.

Manser, M.P. (2009, August). Summary of current teen driver support system technologies. Annual International Conference of the American Association of Motor Vehicle Administrators, San Diego, California.



Janet Creaser

Manser, M., Creaser, J., Rakauskas, M., Graving, J., Donath, M., and Shankwitz, C. (2009, November). Driver adaptation to an intersection-based collision avoidance

system. Fourth International Conference on Driver Behavior and Training, Amsterdam, Netherlands.

Manser, M.P., Rakauskas, M., Creaser, J., Donath, M., Shankwitz, C., and Starr, R. (2009, August). Improving driver behavior at rural intersections: Issues to be considered when designing stop sign assist and gap detection support systems. National Rural ITS Conference, Seaside, Oregon.

Olsen, M., Deokar, S., Willemsen, P., Erickson, S., and Yonas, A. (2010, April). Snow rendering for interactive snowplow simulation—improving driver ability to avoid collisions when following a snowplow. CTS 21st Annual Transportation Research Conference, St. Paul, Minnesota.

Olsen, M., Deokar, S., Willemsen, P., Erickson, S., and Yonas, A. (2010, March). Improving driver ability when following a snowplow in winter. PIVE 2010/IEEE Virtual Reality Conference, Waltham, Massachusetts.

Papanikolopoulos, N.P. (2010, May). Camera networks for surveillance. IEEE Conference on Robotics and Automation, Anchorage, Alaska.

Papanikolopoulos, N.P. (2009, December). Camera networks for surveillance. Tech Forum, Electronics Chapter, 3M, St. Paul, Minnesota.

Papanikolopoulos, N.P. (2009, October). Camera networks for surveillance. Normandale Community College, Minneapolis.

Papanikolopoulos, N.P. (2009, August). Camera networks for surveillance. 2009 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS '09), St. Louis, Missouri.

Parthasarathi, P., Srivastava, A., Geroliminis, N., and Levinson, D. (2010, January). The importance of being early.

89th Annual Meeting of the Transportation Research Board, Washington, D.C.

Rajamani, R. (2009, December). Battery-less, wireless traffic sensors. ITS Institute Advanced Transportation Technologies Seminar Series, University of Minnesota, Minneapolis.

Rosandich, R. (2009, December). Robotic painter prototype: progress report. University of Minnesota Duluth.

Rosandich, R. (2009, July). Improve safety and efficiency of roadway maintenance using robotics phase I: robotic painter prototype. Northland Advanced Transportation Systems Research Laboratories board meeting, University of Minnesota Duluth.

Schooley, B., Hilton, B., Lee, Y., McClintock, R., and Horan, T. (2010, May). CrashHelp: a GIS tool for managing emergency medical responses to motor vehicle crashes. Seventh International Conference on Information Systems for Crisis Response and Management, Seattle.

Schooley, B., and Horan, T. (2009, June). EMS design perspectives: leveraging performance through IT. Emergency Medical Services Administrators Association of California (EMSAAAC) Annual Meeting, Palm Springs, California.

Schooley, B., Horan, T., Marcus, B., and McClintock, R. (2009, November). Health outcomes for motor vehicle accident victims treated at the Mayo Clinic. American Medical Informatics Association (AMIA) Annual Meeting, San Francisco.

Shankwitz, C. (2010, February). Driver assist for bus-only shoulders. Metro Transit Managers' Meeting, Minneapolis.

Shankwitz, C. (2010, January). Driver assist for bus-only shoulders. Plenary Talk, ION International Technical Meeting, San Diego.

Shankwitz, C. (2009, October). Driver assist for bus-only shoulders. ITS Minnesota, St. Paul, Minnesota.

Shankwitz, C. (2009, July). Intelligent vehicle technology. University of St. Thomas Teacher Academy, University of Minnesota, Minneapolis.

Shankwitz, C., and Abegg, M. (2009, November). Driver assist for bus-only shoulders. Department of Mechanical Engineering Seminar Series, University of Minnesota, Minneapolis.

Shankwitz, C., and Abegg, M. (2009, October). Driver assist for bus-only shoulders. Institute of Navigation Northstar Inaugural Chapter Meeting, Minneapolis.



Bryan Newstrom

Shankwitz, C., Newstrom, B., and Kurshoff, E. (2010, May). Demonstration of bus 2.0. ITS America Annual Meeting and Exposition, Houston.

Smith, T.J. (2009, November). Safety and signing for uncontrolled pedestrian crosswalks. CTS Transportation Safety and Traffic Flow Research Council, Regional Planning and Policy Discussion Series, Minneapolis.

Stephanedes, Y.J., Davis, G.A., and Hourdos, J. (2009, June). A modeling framework for crashes and conflicts as dynamic precursors to freeway congestion. Second International Symposium on Freeway and Tollway Operations, Honolulu, Hawaii.

Willemsen, P., Olsen, M., Erickson, S., and Yonas, A. (2010, May). Improving driver ability to avoid collisions when following a snowplow. 2010 Vision Sciences Society Annual Meeting, Naples, Florida.

Yu, X. (2010, March). Real-time non-intrusive detection of driver drowsiness. ITS Minnesota Annual Meeting and Information Exchange, St. Paul, Minnesota.

Yu, X. (2009, November). Real-time non-intrusive detection of driver drowsiness. ITS Institute Advanced Transportation Technologies Seminar Series, University of Minnesota, Minneapolis.

Zhou, D., Dillion, M., and Kwon, E. (2009, December). Tracking-based deer vehicle collision detection using thermal imaging. IEEE International Conference on Robotics and Biometrics, Guilin, Guangxi, China.



## EDUCATION

The ITS Institute's education activities consist of a multidisciplinary program of coursework and experiential learning that supports the Institute's theme. The educational program includes the disciplines of computer science and engineering, electrical and computer engineering, civil engineering, mechanical engineering, human factors, public policy, and others.

By supporting and sponsoring a variety of educational initiatives for students, the Institute is generating interest in its core ITS science and technologies. These initiatives include developing new curriculum and courses, involving undergraduate and graduate students in research projects, sponsoring students to attend national conferences, giving awards that recognize outstanding students, and offering research assistantships to help attract more students to the study of transportation. This section of the annual report highlights some of our efforts in the area of education.

### **Transportation experts from industry, academia present at seminar series**

At the 2009 Advanced Transportation Technologies Seminar Series, five University of Minnesota faculty members and two visiting researchers presented their ITS-related projects. The effect of privacy laws on ITS technology, a driver drowsiness detection system, and the impact of alcohol consumption on motorcycle drivers were some of the featured topics.

The fourth presenter in the series, visiting professor Lily Elefteriadou, discussed her work using real-time freeway congestion data to enhance the performance of ramp-metering systems. Elefteriadou, the director of the Transportation Research Center and a professor at the University of Florida, is the leader of a study examining how ramp meter decisions could delay traffic breakdown and increase freeway capacity.

Elefteriadou and her team collected data for one year at six sites, including a segment of I-94 between Bass Lake

Road and Rockford Road in the Twin Cities metro area. They then calculated the likely time of traffic breakdown—defined as the beginning of recurring congestion on a section of road—in key bottleneck areas.

When the researchers used a traffic simulator to see how their breakdown probability model worked at the Minnesota site, Elefteriadou said, they encountered challenges. When the team tried to reduce congestion at a downstream ramp, the traffic queue at an upstream ramp increased.

“You’re always playing a balancing game between trying to avoid congestion on the freeway and not extending the queue too long on the ramp,” Elefteriadou said. She noted, however, that breakdown was postponed for several minutes during peak periods. The congestion’s duration was shortened, and travel time for drivers was reduced.

“It shows some promise,” Elefteriadou concluded, “particularly at locations with adequate local data for breakdowns.”

Other presentations in the series were:

- “The Implications of Current and Emerging Privacy Laws for ITS,” Frank Douma, assistant director, State and Local Policy Program, Humphrey Institute of Public Affairs
- “Effects of Alcohol on Motorcycle Riding Skills,” Janet Creaser, research fellow, HumanFIRST Program
- “Relieving Congestion and Saving Energy by Cooperative Intelligent Transportation Systems,” Steve Shladover, research engineer, California Partners for Advanced Transit and Highways
- “Should I Drive or Should I Talk?” Ensar Becic, research associate, HumanFIRST Program
- “Non-Intrusive Detection of Driver Drowsiness,” Xun Yu, assistant professor, Department of Mechanical and Industrial Engineering, University of Minnesota Duluth
- “Battery-Less, Wireless Traffic Sensors,” Rajesh Rajamani, professor, Department of Mechanical Engineering

This was the ninth year that the Institute sponsored the multidisciplinary seminars, during which researchers report on findings from their work and bring new information to the ITS community. The series is offered as a one-credit graduate-level course, or attendees can earn one professional development hour for each seminar. Presentations are recorded and available for viewing on the Web.

### Institute funds student travel

The ITS Institute gave travel awards to 15 students so they could attend national meetings and conferences.

Institute for Operations Research and the Management Sciences (INFORMS) Annual Meeting, San Diego, Calif. (Fall 2009):

- |                |                 |
|----------------|-----------------|
| • Fang Chen    | • Xinkai Wu     |
| • Xiaozheng He | • Shanjiang Zhu |

2009 American Society of Mechanical Engineers (ASME) Dynamic Systems and Control Conference, Hollywood, Calif. (Fall 2009):

- Gurkon Erdogan

Women’s Transportation Seminar (WTS) Annual Conference, Washington, D.C. (Spring 2010):

- Avital Barnea

89<sup>th</sup> Annual Meeting of the Transportation Research Board, Washington, D.C. (Winter 2010):

- |                       |                 |
|-----------------------|-----------------|
| • Indrajit Chatterjee | • Arthur Huang  |
| • Brian Davis         | • Saif Jabari   |
| • Yiheng Feng         | • Lyssa Leitner |
| • Feili Hong          | • Pavithra      |
| • Heng Hu             | Parthasarathi   |

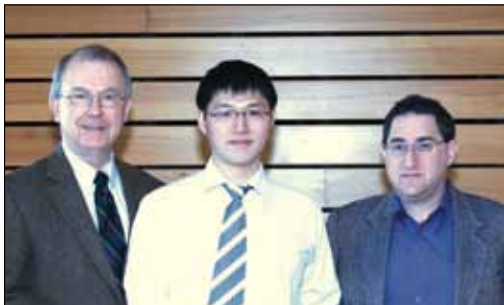


*Research on the effects of alcohol on motorcycle riding skills was the topic of an Advanced Transportation Technologies seminar held in the fall.*

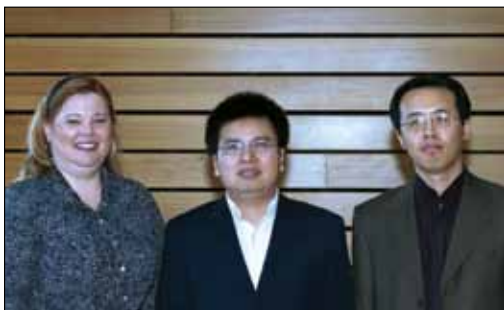




Max Donath, Fay Cleaveland, and Frank Douma



John Adams, Shanjiang Zhu, and David Levinson



Gina Baas, Xinkai Wu, and Henry Liu

## Engineering, planning students honored for work

Three graduate students conducting ITS-related research received awards at the Center for Transportation Studies' annual meeting and awards luncheon April 7 in Minneapolis.

Xinkai Wu, a doctoral candidate in civil engineering, was a recipient of the Matthew J. Huber award, named in honor of the late Professor Emeritus Matthew J. Huber and given to students in engineering, science, and technology fields. Wu's research contributed to the development of a patent-pending arterial performance measurement system. His advisor is Assistant Professor Henry Liu, who said Wu was "a major force for the development of SMART-Signal and has a real passion for his work."

Shanjiang Zhu, a doctoral candidate in civil engineering and a master's of science candidate in applied economics, received the John S. Adams Award, given to students in policy and planning fields. Zhu's research examined the route choice behavior of individual travelers before and after the reopening of the I-35W Bridge. His advisor, Associate Professor David Levinson, said Zhu was the "single hardest-working grad student" he has advised in his years at the University.

The U.S. Department of Transportation's Research and Innovative Technology Administration presents an outstanding student of the year award to each of its University Transportation Centers (UTCs). The recipient of the 2009 award at the ITS Institute is Fay Cleaveland, a recent graduate with a master's degree in urban and regional planning. Max Donath, the director of the Institute, presented the award. Cleaveland's work included research on e-shopping and its effect on traffic conditions, bicycle facilities, and public policy. Since graduating from the Humphrey Institute, Cleaveland has begun a career as a transportation planner at the Minnesota Department of Transportation. Her advisor, Humphrey Institute research fellow Frank Douma, praised Cleaveland's work, including her publication in a national journal.

## Traffic game goes viral

People everywhere are trying their hand at traffic engineering, albeit virtually, by playing "Gridlock Buster," a traffic control game developed by the ITS Institute and Web Courseworks. (The Institute funded Web Courseworks to enhance the first version of the game, created by the Institute's educational systems manager Chen-Fu Liao.)

The goal of Gridlock Buster is to provide a fun way to teach students what is involved in traffic grid management and make transportation interesting and relevant. But over the past year, the game's popularity has gone beyond that.

Institute program coordinator Shawn Haag says Web Courseworks put the game on Kongregate.com, a Web site that allows users to play thousands of free online games, but postings didn't stop there. The game is an open source file and can be linked to multiple Web sites. A Google search shows at least 10 other sites hosting the game, including play181.com, gamesforwork.com, and fupa.com. Additionally, the game can be embedded into a personal blog. Since its original posting online, Gridlock Buster has garnered more than 2 million game plays.

The Web isn't the only place the game has seen a higher profile. It has been used at area high schools as a recruiting tool, as well as at the University of Minnesota Institute of Technology's summer camp, Haag says. "For high-schoolers, it's fun to play," Haag adds, "but tying in curriculum enhances the experience. It makes for a well-rounded two-and-a-half-hour program."

The game has also been used by university undergrads as part of their coursework and by elementary school children at events such as TechFest, in which the Institute participated. And it was demonstrated at the 2009 Minnesota State Fair.

Additionally, the game is being used as a training tool. Paul Olson, an ITS engineer with the Federal Highway Administration in Colorado, recently showed the game to police officers in Puerto Rico. "They have a

problem with the police breaking into traffic controllers to shut them down, then manually controlling traffic. It's a mess to say the least," Olson says. The game is a way to educate police and show them it's not a good practice. If officers feel they must manually operate the controllers for political reasons, Olson adds, then the tool can at least teach them how to control traffic more effectively.

### **STREET creates new learning tools for transportation courses**

STREET (Simulating Transportation for Realistic Engineering Education and Training) is a project focused on developing a set of Web-based simulation modules and other learning tools for use in introductory undergraduate transportation engineering courses. The modules are also suitable for upper-division transportation courses and cover a variety of topics fundamental to the practice of transportation engineering, including travel demand modeling, geometric design, traffic flow, and traffic signal control. Minnesota Traffic Observatory educational systems manager Chen-Fu Liao is a key member of the development team.

As part of the STREET project, Associate Professor David Levinson and his students at the University of Minnesota's Department of Civil Engineering developed an online simulation model for transportation planning called the Agent-Based Demand and Assignment Model (ADAM). ADAM is intended for classroom use as a tool for introducing students to the fundamental concepts of travel forecasting in a user-friendly, interactive format. It was first tested in a classroom setting in 2005 in an introductory transportation engineering course at the University of Minnesota.

The Web-based modules developed as part of the STREET project complement a wikibook titled *Fundamentals of Transportation*. The modules were



*A Trent Tucker program participant practiced traffic management concepts while playing Gridlock Buster.*

tested in 2009 in the curricula of a number of undergraduate transportation engineering courses at various universities. More than a dozen faculty members have agreed to incorporate STREET into their curricula at the following Universities:

- Portland State University
- Utah State University
- University of California at Davis
- University of Arizona
- Georgia Institute of Technology
- University of Massachusetts-Amherst
- Northwestern University
- Western Michigan University
- University of Illinois at Urbana-Champaign
- University of Virginia
- University of California, Irvine
- Rennselaer Polytechnic Institute

- University of Texas at Austin
- University of Washington
- Oregon State University
- Texas A & M

### Pre-college students try technology at transportation camps, exhibits

During the past fiscal year, the ITS Institute has participated in several events, camps, and high school visits to introduce K-12 students to transportation and ITS-related fields of study.

► The ITS Institute participated in the **IT Exploring Careers in Engineering and Physical Science Summer Camp**, hosted by the Institute of Technology last summer. The day camp, offered every June and July, is designed to introduce high school students to potential careers in science, engineering, and math. The Institute participated

for two days in July, when David Glick taught 30 high school students how to play Gridlock Buster using the traffic engineering curriculum he developed.

► On July 9, approximately 50 students from the **Fond du Lac Community College Summer Transportation Camp** learned about transportation research at the University of Minnesota. This was the seventh consecutive year the University hosted the group, which consists of students of all ages from Cloquet, Minn., and the surrounding communities. The camp, which receives funding from the Federal Highway Administration (FHWA) National Summer Transportation Institute Program, is designed to encourage students to explore careers in transportation-related fields. This year's visit was highlighted by tours of the Minnesota Traffic Observatory and the Department of Civil Engineering's civil structures lab.

► The University also hosted the **Leech Lake Transportation Camp** in the summer of 2009. This was the first year of Leech Lake's program, also funded by the FHWA. About 20 students toured the University of Minnesota campus, visited the robotics lab, and witnessed a demonstration of Gridlock Buster.

► In August, the Institute assisted the Center for Distributed Robotics and the Digital Technology Center with a **Technology Day Camp**. This program, organized by Center for Distributed Robotics director Nikolaos Papanikolopoulos and his graduate students, targets primarily underprivileged middle school students from the Twin Cities area, giving them the chance to explore technology and robotics. The 30 participants in the camp, who attended free of charge, toured campus labs, learned about computer programming, and experimented with robots. One tour was of the aerospace engineering department with Associate Professor Demoz Gebre-Egziabher.

*IV Lab researcher Eddie Arpin helped students prepare for the FIRST LEGO League robotics competition when they came to campus.*





► The Institute partnered with CTS and High Tech Kids to host more than 250 young science enthusiasts and 100 parents on October 13 to help them prepare for “Smart Move,” the 2009 **FIRST LEGO League robotics competition**. The 2009 competition challenged students to build small autonomous robots that accomplished transportation-related tasks. ITS Institute director Max Donath began the day by highlighting the transportation research projects under way at the University of Minnesota. Students then took a tour of the Minnesota Traffic Observatory and witnessed demonstrations of the lab’s equipment. Other activities included graduate student presentations on such topics as driver-assistive systems and robotics, a demonstration of Gridlock Buster, and a presentation on road safety featuring the interactive Web site SafeRoadMaps.org.

► The Institute staffed a booth at **TechFest** in Edina for the third consecutive year. The one-day event held at The Works museum in February featured a variety of interactive transportation exhibits and attracted more than 2,000 attendees. The Institute’s booth featured seven computer stations where children could try their hand at Gridlock Buster. Also on display was a working camera from the Beholder system—the traffic data collection system currently used by Minnesota Traffic Observatory (MTO) researchers on the I-35W/I-94 freeway commons. TechFest visitors could see themselves captured in the traffic camera and displayed on a nearby laptop.

► About 60 middle school students participating in the **Trent Tucker University Scholars Program** played Gridlock Buster on February 10. The program, offered to sixth- and seventh-grade students after school every Wednesday during spring semester, is designed to promote early college awareness and introduce students to science and engineering topics. Besides using Gridlock Buster, students heard a presentation on transportation careers.

► Also in February, the Institute hosted a **webinar** to teach educators how to use **Gridlock Buster** in the classroom. Among the attendees was Bondo Nywenbe, the director of the Richard Allen Math and Science Academy, a new charter school in North Minneapolis with approximately 50 middle school students. Nywenbe was interested in using Gridlock Buster on a computer in the school’s “Rewards Room,” a place for students to celebrate their scholastic successes.

► On April 15, the ITS Institute participated in **Engineering Day** at Mahtomedi High School. Shawn Haag, program coordinator for the Center for Transportation Studies (CTS) and the ITS Institute, demonstrated Gridlock Buster to students ages 6 to 15. The event, part of Mahtomedi’s Engineering Leadership Program, invited exhibitors to showcase their projects and research in science, technology, engineering, and mathematics. Students and parents witnessed demonstrations on robotics, forensics, wind turbines, and many other topics.

*Young TechFest visitors learned about traffic data collection at the Institute’s exhibit.*





# TECHNOLOGY TRANSFER

The Institute could not accomplish its goals without sharing its expertise and research results with local, national, and international audiences for use in real-world applications. Technology transfer also communicates to the world who we are—raising the profile of the Institute and its research—and educates students, policymakers, and the general public about ITS issues and solutions.

Our efforts in this area are far-ranging to reach a broad and diverse audience of researchers, students, practitioners, policymakers, and others among the public. Over the past year, we have provided tours and demonstrations of our research and facilities, sponsored seminars, sent electronic newsletters and announcements, published printed pieces, and enhanced our Web site. But perhaps the most direct method of transferring technology has been to send graduating students out into the workforce.

This section of the annual report highlights some of our technology transfer activities over the past year.

## Human factors key to safe road design

If it looks like a freeway and acts like a freeway, motorists are likely to treat it like a freeway—even if the road in question is a suburban arterial. How drivers respond to the “road message” has important implications for safety, said human factors expert Alison Smiley in her presentation at the 2010 CTS Winter Luncheon. The February 9 luncheon was sponsored by the ITS Institute.



*Alison Smiley*

Smiley is president of HumanFactors North, Inc., adjunct professor in the Department of Mechanical and Industrial Engineering at the University of Toronto, and adjunct professor in the Department of Civil Engineering at Ryerson University. In her presentation, titled “Saving

Us from Ourselves: Human Factors and the Design of Safer Roads,” Smiley brought a human factors perspective to issues of road design.

Human factors analysis can contribute to road safety in several important ways, Smiley said. As an example of how human limitations affect road safety, Smiley explained that the human visual system gives drivers cues about changes in the distance between vehicles. Because this visual cue is nonlinear, drivers find it difficult to distinguish between a gradual approach to another vehicle and a dangerous rapid approach until they are too close to the other vehicle. This limitation contributes to many rear-end crashes. Knowing about this limitation enables us to design effective countermeasures to address the problem, Smiley explained.

Smiley went on to discuss the role of human factors in road design standards. Understanding how drivers process information can help designers avoid overloading drivers with too many complex tasks, she said.

### Partnership award goes to automated deicing research

An automated system to reduce the unnecessary use of roadway deicing chemicals received this year’s CTS Research Partnership Award. The annual award recognizes research projects within the CTS program, which includes the ITS Institute, that have resulted in significant impacts on transportation and rewards teams of individuals who have drawn on the strengths of their diverse partnerships to achieve those results.

“Automated Friction Measurement, Data Recording, and Applicator Control for Winter Road Maintenance” developed a tire-road friction measurement system for snowplows and a closed-loop control system that uses these friction measurements for automatic applicator control. By measuring friction, only spots on the road that are



*Dan Warzala, Farideh Amiri, Curtis Gobeli, Dharam Bobra, Brian Scott, Rajesh Rajamani, Lee Alexander, Dawn Spanhake*

indicated as icy are treated with deicing chemicals, which reduces unnecessary use of chemicals—and thus, costs. The equipment uses a GPS system to provide quantitative data on winter maintenance operations—data that could be disseminated as public information on travel routes. The technology is being prepared for limited deployment in two snowplows and one pick-up truck. [For more on this research, see page 21.]

In accepting the award for the team members, Professor Rajesh Rajamani of the Department of Mechanical Engineering thanked Mn/DOT for sponsoring the research, the ITS Institute for providing initial funds, and the Technical Advisory Panel members and Mn/DOT staff who were involved. Project partners were:

- University of Minnesota: Lee Alexander, Gurkan Erdogan, Rajesh Rajamani
- Mn/DOT: Curtis Gobeli, Farideh Amiri, Gabe Guevara (now with the Federal Highway Administration), Roger Hille, Sue Lodahl, Mark Panek, Dan Warzala, Thomas Zimmerman,
- SRF Consulting Group, Inc.: Brian Scott
- Hennepin County: Dharam Bobra





*The Teen Driver Support System is a GPS-enabled smart phone mounted on the dashboard.*

### **Institute research showcased in demos, tours, and exhibits**

► A new version of the Teen Driver Support System (TDSS), in development at the ITS Institute, took center stage June 4 at a **teen safe driving forum** held at Anoka-Ramsey Community College in Cambridge, Minnesota.

U.S. Rep. James Oberstar and transportation safety experts, including ITS Institute director Max Donath, introduced and solicited feedback on the potentially life-saving technology and called on parents to set an example by holding their children accountable. Oberstar received a live demonstration of the TDSS in a test vehicle just prior to the forum.

“You can change habits if parents take responsibility,” Oberstar said. “It’s not just the teenager. Most of what we learn, we learn by example from our families.”

TDSS is a GPS-enabled smart phone mounted on the dashboard to provide the driver real-time visual and audio feedback about driving behavior. (Other phone functions are disabled while the TDSS is in use and the car is on. All incoming calls are routed to voicemail and no outgoing calls or texting is possible, except for 911 emergency calls.) The device is intended as a tool for parents to help teens develop safe driving habits.

Donath explained that the system provides parents

with data about their teen’s driving behavior. This is especially important on rural roads, which account for the majority of fatal highway crashes.

“We bother the parent,” Donath said. “When the teen is breaking the rules, such as speeding or driving with too many passengers, there need to be consequences, and at this age, the only people who can really enforce the rules are the parents.”

Isanti County Judge James Dehn moderated the forum, which also featured presentations by Gordy Pehrson, Youth Traffic Safety and Alcohol Grant coordinator for the Minnesota Department of Public Safety, and Lee Munnich, director of the Center for Excellence in Rural Safety at the University of Minnesota.

Earlier that week, Donath and research fellow Alec Gorjestani demonstrated the TDSS to U.S. Senator Amy Klobuchar and David Strickland, administrator with the National Highway Traffic Safety Administration, as part of a teen driving safety forum held June 1 at Tartan High School in Oakdale, Minnesota.

“To make a lasting difference, it’s going to take all of us working together—law enforcement, educators, parents, and teens,” Klobuchar said. “Ultimately, what we need is a change in what society views as acceptable and unacceptable behavior.”

The TDSS project is cosponsored by the ITS Institute and the Minnesota Department of Transportation.

► A group of researchers from the ITS Institute’s Intelligent Vehicles Laboratory (IV Lab) traveled to the **ITS America Annual Meeting and Exposition**, held May 3–5 in Houston, to demonstrate their driver-assistive technologies for bus rapid transit (BRT) applications. IV Lab director Craig Shankwitz and staff Bryan Newstrom and Erin Kurshoff, along with Mike Abegg from the Minnesota Valley Transit Authority (MVTA), showcased the driver-assistive system developed by the IV Lab for use in MVTA buses. On May 4, the team gave a demonstration to U.S. Department of Transportation

*Senator Amy Klobuchar, Max Donath, Eddie Arpin, and David Strickland*





*Craig Shankwitz (right) explained the driver-assistive technology to RITA administrator Peter Appel.*

administrators and staff, including Peter Appel, administrator of the Research and Innovative Technology Administration (RITA); Peter Rogoff, administrator of the Federal Transit Administration (FTA); Anne Ferro, Federal Motor Carrier Safety administrator; Polly Trottenberg, assistant secretary for transportation policy; Brian Farber, associate administrator for communications and congressional affairs; Gail Lyssy, FTA Region VI director of program management and oversight; and John Augustine, deputy director of the ITS Joint Program Office, RITA. Also attending was Paul Feenstra, ITS America's vice president of government affairs.

The expo demonstration featured an MVTa bus equipped with the driver-assistive system and a monitor showing video captured by a camera on the driver's forehead. On board, the team used an extra seat and steering wheel to let passengers view the HUD technology as well as experience the different modes of feedback the IV system provides to the driver. The demos took place on roads and road shoulders near the George R.

Brown Convention Center in Houston. The IV Lab research team worked closely with representatives from the Metropolitan Transit Authority of Harris County (home to Houston), to map the lanes and arrange police escorts during the demonstrations.

A fleet of 10 buses equipped with the new system is scheduled to go into service in the Twin Cities in 2010 as part of an effort to reduce congestion and improve public transportation. The high-tech "Bus 2.0" vehicles will be operated by the Minnesota Valley Transit Authority along the I-35W/Cedar Avenue commuting corridor that connects downtown Minneapolis and the southern suburbs. The technology developed by the IV Lab will help bus drivers maintain reliable schedules while operating safely on the narrow bus-only highway shoulders.

► This same driver-assistive system for buses took center stage at the 2009 **ITS Minnesota Fall Forum**, where it was demonstrated by Craig Shankwitz. The annual event, sponsored by the Minnesota chapter of ITS America, brings together companies, transportation professionals, and researchers to exchange information on ITS projects around the state.

► A bus was also exhibited at the **2010 St. Paul Winter Carnival** in January, in conjunction with a display promoting the first Autonomous Snow Plow Competition of the Institute of Navigation's North Star Section.

► The University of Minnesota was the site of a **"town hall" discussion on U.S. transportation policy** on January 25, part of a nationwide listening tour led by U.S. Transportation Secretary Ray LaHood and U.S. Rep. James Oberstar, chairman of the House Transportation and Infrastructure Committee. LaHood and Oberstar solicited feedback from local transportation stakeholders on the next surface transportation bill.

Among those in attendance was Peter Appel, administrator of the Research and Innovative Technology



*Bus 2.0 was exhibited at the 2010 St. Paul Winter Carnival in downtown St. Paul.*



*U.S. Rep. James L. Oberstar in the HumanFIRST driving simulator*

Administration (RITA). “This administration and this DOT are committed to transportation research,” he said, adding that he is pleased to see the leadership of the University of Minnesota in the area of intelligent transportation systems

During a working lunch, USDOT leadership discussed the vision, priorities, and challenges for their respective modes. In opening remarks, Laurie McGinnis, then-acting director of CTS (and chair of the ITS Institute Board), discussed the importance of research in the next bill. As an example, she cited ITS Institute research that is developing in-vehicle systems to encourage safe driving by teens and support effective parental supervision of inexperienced drivers.

► Congressman Oberstar also visited the University of Minnesota on November 12 for an update on the latest University transportation research. He met with Transportation Engineering and Road Research Alliance (TERRA) board members, tried out the HumanFIRST driving simulator, and toured the Minnesota Traffic Observatory, guided by Laurie McGinnis and Max Donath. “I love what you’re doing here,” Oberstar said.

► In September, the ITS Institute and the Center for Transportation Studies participated in the 2009 **Minnesota State Fair** with a booth featuring Gridlock Buster, an interactive traffic-control game designed by the ITS Institute. In addition, Minneapolis *Star Tribune* “Roadguy” blogger Jim Foti hosted four rounds of “Transportation Jeopardy” as fairgoers competed for prizes.

► In August, a team of University officials hosted a session on the ITS Institute’s Teen Driver Support System (TDSS) at the annual **American Association of Motor Vehicle Administrators (AAMVA) conference** in San Diego. Mike Manser, director of the Institute’s HumanFIRST program; Frank Douma, assistant director of the State and Local Policy Program at the Humphrey Institute; and Gina Baas, assistant director of education and outreach at the Center for Transportation Studies, spoke to motor vehicle licensing administrators about TDSS and its potential for interaction with graduated driver’s license (GDL) regulations.

The University officials discussed how the TDSS, which takes over the teen’s cell phone to detect such GDL-related factors as number of passengers and driving after curfew, could work with GDL regulations from both a parental and administrative standpoint. The AAMVA conference attendees drew on their extensive experience with GDL laws and training young drivers to provide feedback on the TDSS’s potential. The system’s ability to help parents understand their teen’s compliance with GDL standards, as well as issues such as the system’s data privacy implications, were among the topics discussed.

► Others who toured the ITS Institute facilities during the past year include:

- Congressional transportation staffers Travis Talvitie and Kelly Scanlan, U.S. Senator Amy Klobuchar’s office
- Bill VanTassel, manager of driver training programs, AAA
- Tim Johnson, director of the Office of



Human-Vehicle Performance Research, National Highway Traffic Safety Administration

## Institute researchers discuss transportation at local and national events

► Institute director Max Donath presented at the second-annual **Symposium on Mileage-Based User Fees** in April in Minneapolis, which focused on methods and approaches to further the development of mileage-based road user fees. Donath shared findings from Institute research exploring technology to enable nationwide implementation of user fees.

► ITS Institute researchers discussed their work at the **21<sup>st</sup> Annual CTS Transportation Research Conference** in St. Paul, Minnesota. Presentations included:

- “The Effectiveness of Changeable Message Signs and the Aging Population,” Kathleen Harder, Center for Design in Health
- “Lessons Learned from eWorkPlace, a State-Sponsored Telework Initiative in the Twin Cities,” Adeel Lari, Humphrey Institute of Public Affairs
- “Snow Rendering for Interactive Snowplow Simulation—Improving Driver Ability to Avoid Collisions When Following a Snowplow,” Peter Willemsen, Department of Computer Science (Duluth)
- “ITS and Privacy: Suggestions for Peaceful Coexistence,” Frank Douma; Humphrey Institute of Public Affairs; Sara Aue, University of Minnesota Law School
- “Should the Fuel Tax be Replaced?” Lee Munnich, Humphrey Institute of Public Affairs,
- “Freight Performance Analysis on I-94/ I-90 from the Twin Cities to Chicago,” Chen-Fu Liao, Minnesota Traffic Observatory (MTO)

- “Mining Bus Location, Passenger Count and Fare Collection Database for Intelligent Transit Applications,” Chen-Fu Liao, MTO, and Henry Liu, Department of Civil Engineering

► Showcasing the diversity of ITS research at the University of Minnesota, a trio of researchers presented new technologies and recent research results at the **ITS Minnesota 16th Annual Meeting & Information Exchange** on March 9.

Professor Rajesh Rajamani, Department of Mechanical Engineering, discussed a new type of wireless traffic sensor under development in his lab that does not rely on batteries or external power sources. The sensors, based on piezoelectric technology, convert the mechanical energy of vehicles passing over them to electrical energy to power their highly efficient sensing and data-transmission systems.

Assistant Professor Xun Yu, Department of Electrical and Computer Engineering, Duluth, outlined the development of an in-vehicle sensor system designed to detect driver drowsiness. Yu’s approach is based on polymer-film sensors mounted on the steering wheel, which detect a driver’s heart rate through his or her palms and tracks changes in heart rate that can indicate a transition from waking to sleeping.

Frank Douma, assistant director of the State and Local Policy Program at the Humphrey Institute, presented recent findings from his investigation of the legal and policy implications of new ITS technology deployments.

► Institute researcher and mechanical engineering professor Rajesh Rajamani was the plenary speaker at the **29th IASTED International Conference** on Modeling, Identification and Control, held in Innsbruck, Austria, in February 2010. He presented “Novel Sensors, New Estimation Algorithms and Advanced Controls: Solutions for Improving Highway Vehicle Safety and Mobility.”



*Lee Munnich was among the presenters at the annual CTS Transportation Research Conference.*



Max Donath discussed his research at the *Toward Zero Deaths* conference in October.

► Institute researchers presented their work at the **Transportation Research Board (TRB) 89<sup>th</sup> Annual Meeting**, held January 10–14 in Washington, D.C. Among the presentation topics were distance-based fees for funding transportation, congestion pricing and traffic modeling in networks, the effects of e-shopping on travel, and enhancing student understanding of core transportation concepts.

University of Minnesota faculty, staff, and student presenters included:

- Max Donath, ITS Institute
- Lee Munnich, Frank Douma, Xinyu (Jason) Cao, and Fay Cleaveland, Humphrey Institute of Public Affairs
- John Hourdos and Chen-Fu Liao, Minnesota Traffic Observatory, ITS Institute
- Gary Davis, David Levinson, Henry Liu, Xiaozheng He, Shanjia Zhu, Xiaolei Guo, Xuan Di, Adam Danczyk, Nebiyu Tilahun, Pavithra Parthasarathi, and Anupam Srivastava, Department of Civil Engineering
- Shawn Haag and Gina Baas, Center for Transportation Studies

► Institute researchers also spoke at the annual **Toward Zero Deaths Conference** October 28–29, 2009, in Duluth, Minnesota. The conference serves as a forum for sharing information on how to reduce the number of fatalities and injuries on Minnesota roads. Presenters included Institute director Max Donath, speaking in a session titled “Safe Intersections Through Technology,” and Lee Munnich, discussing traffic safety in rural Minnesota.

► At the annual **Summer Institute** of the Center for Excellence in Rural Safety (CERS), held August 3 and 4 in Williamsburg, Virginia, leading state and national transportation officials, researchers, policymakers, and professionals gathered to share information and develop strategies for improving rural transportation safety. Institute researchers who presented included Tom Horan, who gave an update of research into rural emergency response

times, and Max Donath, who described a variety of available technologies with the capability to reduce rural fatalities and life-changing crashes.

## **Publications, Web services highlight Institute work**

In November 2009, the Institute implemented blog software to streamline the management of news and events on the Web site. The software also creates an RSS news feed for that content automatically. Search engine optimization has improved the ability of search engines to find information from the Institute in response to search terms related to its work.

Electronic communications continue to play an important role in quickly disseminating information. In November, the Institute launched a new electronic newsletter, the *ITS Institute Update*, to reach the ITS community more quickly and to report on our activities in the areas of research and education. The bimonthly publication, which mails electronically to nearly 1,200 individuals, is designed to enable readers to scan the contents and then link to the Institute’s Web site for further information.

E-mail announcements publicized upcoming events, including Advanced Transportation Technologies Seminars, conferences, luncheon presentations, and other ITS-related events. The seminars and luncheon presentations are now regularly broadcast live on the Web as well as recorded for later viewing. They are also available through iTunesU.

Eight ITS-related research projects were featured in the Center for Transportation Studies’ *Research E-news* electronic newsletter, which is mailed to about 4,000 subscribers and is available on the Web at [www.cts.umn.edu/Publications/ResearchENews](http://www.cts.umn.edu/Publications/ResearchENews). These articles also provide links to more information about each project.

In other efforts to explore new channels of



*The Institute implemented blog software to streamline the management of news and events on its Web site.*

communication and reach new audiences, staff created a four-minute video about the Teen Driver Support System to explain and promote the technology. The video was first shown at a teen driver safety forum with U.S. Rep. James Oberstar in June and will later be available for viewing on the ITS Institute's YouTube channel and the ITS Institute Web site. More videos are planned for the coming year.

Print publications continued to raise awareness of ITS work in academic and professional communities and share the results of research. The *Sensor* newsletter covered Institute research activities, education, and technology transfer activities; upcoming ITS-related events; and recently published research reports. The *Sensor* is available in print and online and reaches about 2,000 subscribers three times each year. It has been one of the primary vehicles for increasing the visibility of the ITS Institute, and its high circulation testifies to a broad interest in ITS research activities among academic and professional readership.

The 11th ITS Institute annual report (fiscal year 2008–09), highlighting work by the Institute's researchers and students, was mailed to more than 1,400 individuals and is available as a PDF file downloadable from the Institute's Web site.

## Visiting researchers share ideas, expertise

During the past year, the Institute continued to work with visiting researchers and instructors, allowing for an exchange of information and dissemination of research results to the visitors' students and colleagues.

The Advanced Transportation Technologies Seminar Series provided an opportunity to host two national researchers. Steven Shladover, research engineer with California Partners for Advanced Transit and Highways (PATH), presented "Relieving Congestion and Saving Energy by Cooperative Intelligent Transportation Systems" on October 8. On October 22, Lily Elefteriadou, a professor at the University of Florida and director of its Transportation Research Center, presented "Ramp Metering for Postponing Freeway Breakdown."

Thomas Horan, an associate professor at Claremont Graduate University and visiting scholar at the Humphrey Institute of Public Affairs, is part of the TechPlan research program. A paper Horan authored with Benjamin Schooley, Brian Hilton, Yoonmi Lee, Rondalynne McClintock, and Samuel-Ojo Olusola was recently selected as "best paper" by the awards committee of the Seventh International Conference on Information Systems on Crisis Response and Management, held May 2010 in Seattle. The paper, "CrashHelp: A GIS Tool for Managing Emergency Medical Responses to Motor Vehicle Crashes," presents the research, design, development and evaluation of a prototype of a comprehensive trauma information system.

Other contributing researchers, all working with the Institute's HumanFIRST Program, include Nobuyuki Kuge and Tomohiro Yamamura of Nissan, Jeff Caird of the University of Calgary, and Dick de Waard of the University of Groningen.



*Visiting scholar Tom Horan is part of the TechPlan research program.*







# *How does the work at the ITS Institute benefit me?*



*More reliable transit schedules*  
(more on page 31)



*Goods and products moved more efficiently*  
(more on page 24)



*Technology that helps prevent serious crashes*  
(more on page 22)



*Better access to destinations*  
(more on page 18)



*Accurate, timely data to inform public policy*  
(more on page 26)



*Safer winter roads and healthier roadsides*  
(more on page 21)

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